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FRIDAY, NOVEMBER 8, 1895.

CONTENTS:

Louis Pasteur: H. W. CONN 601

Pasteur as Illustration of Modern Science: GEORGE BRUCE HALSTED 611

Determination of the Constants of the Diurnal Nutation: F. FOLIE 613

Current Notes in Physiography (XVII.):—

The Labrador Peninsula; Transverse Valleys in the Southern Alps; A Swiss Landslide in the Glacial Period; Valleys in the Plateau of the Ardennes; The Rivers of Spain: W. M. DAVIS 617

Scientific Notes and News:—

Field Work of the U. S. Geological Survey; The 'Institut Pasteur;' The Phenomena of Friction; General 619

University and Educational News 625

Correspondence:—

Experimental Psychology in America: WILLIAM JAMES, GEORGE TRUMBULL LADD, J. MARK BALDWIN, J. MCKEEN CATTELL. *Radiolarian Earths of Cuba:* ROBERT T. HILL. *Erect Vision and Single Vision:* JOSEPH LE CONTE 626

Scientific Literature:—

Hancock's Mechanics and Hydrostatics; Glazebrook's Mechanics: R. S. WOODWARD. *Fourteenth Annual Report of the U. S. Geological Survey; Rolker's Production of Tin:* J. F. KEMP. *Oliver's Natural History of Plants; A Traverse le Caucase:* ELIZABETH BRITTON 630

Societies and Academies:—

Biological Society of Washington: F. A. LUCAS. *The Academy of Science of St. Louis:* A. W. DOUGLAS 635

New Books 636

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LOUIS PASTEUR.

NEVER has the world been called upon to lament the death of one whose life was so full of gifts to humanity as that of Louis Pasteur. Others have lived with equal genius, others there have been whose influence upon thought has been equal or greater. Others have achieved an equal reputation from achievements of various kinds; but no other man in the history of the world has given to mankind so many valuable gifts as those which have come from the labors of Pasteur. That Pasteur possessed great genius is manifest, but yet it was not wholly genius that explains his marked preëminence, for a certain modicum must be attributed to the timeliness of his work. His greatness was due in a measure to the fact that early in life he had the fortune to have presented to his attention and the wisdom to seize upon great problems for solution. He early seized for his own an almost new field of research and brought to this new field an equipment entirely different from that which any other scientist had possessed. Pasteur is regarded as the father of modern bacteriology, but we must remember that he was not a pioneer in these lines of work. There was hardly a problem that he studied which had not been already recognized, and even studied to a greater or less extent by his predecessors; but at the same time there was not a single problem which Pasteur undertook to solve

which was not when he undertook it in a most crude, unsatisfactory condition, and when he left it in its almost perfect form. It was in reaping fruits where others failed, and in perfecting the work which had been begun by less competent scientists, that Pasteur's merit lies. Others discovered facts, Pasteur determined laws.

In looking over the life of Pasteur as a whole we are struck forcibly with two characteristics. The first was its almost uniform success. Doubtless Pasteur occasionally failed in his experimental work. But of this the world has known nothing for his conclusions seem to have been always correct. So far as Pasteur has appeared before the public from the beginning to the end of his career he has enjoyed an uninterupted success. The French people have slowly learned to recognize this and finally acquired such a confidence in him that it has been a popular saying which has met all criticisms that '*Pasteur never makes mistakes.*' This unique testimony of public confidence is unexampled, but it seems to have been well deserved, for certainly no scientist has ever held such a position before the public and made so few mistakes. This is the more remarkable when we remember that he was working in an almost unexplored field. The reason for this uniform success lies primarily doubtless in the nature of the man; but not a little of it we may attribute to the fact that in his early training Pasteur was a chemist rather than a biologist. While Pasteur's reputation will rest upon his work in biology he was educated as a chemist, and to this education we may attribute no little of the uniformity of the success of experiments. The science of biology is extremely inexact. Owing to the complicated conditions of life one is ever expecting to find exceptions to the general rules and our scientists have found it utterly impossible to lay down absolute definitions or any absolute lines of distinction between groups in biological phenomena. The very essence of biological science is the fact that the phenomena grade into each other. Influenced by this fundamental principle biologists have commonly fallen into a habit of slackness in dealing with phenomena. Knowing that whatsoever law they may discover will be sure to have its modifications, its variations and its exceptions, they inevitably get into the habit of feeling that an approximation toward accuracy is almost sufficient. Now the peculiar nature of the field of experimentation in bacteriology demands above all things most rigid accuracy. His training as an analytical chemist gave to Pasteur a recognition of the importance of exactness. One who has carried on experiments in molecular physics recognizes that failure is sure to result from inaccuracy, and it was the fact that until he was 30 years of age Pasteur was trained in this kind of accurate experimental manipulation that, when he turned his attention finally to biology and problems connected with the microscopical world, his methods of experimentation and the results of the experiment showed at once a vast advance over those of all of the biologists which had preceded him. For the first time accuracy began to be seen in this field.

A second striking feature in Pasteur's life was its dramatic character. One hardly looks for the dramatic in the achievement of scientific results. But Pasteur was a Frenchman, and, although thoroughly modest, he was, like other Frenchmen, alive to the advantage of public demonstrations. As we look through his life we can see him taking many and many an opportunity of presenting his scientific results in as dramatic a style as possible. Meeting with opposition almost constantly during the years of his active investigations, time and time again he planned public tests in which his results should be brought before the

public eye for demonstration in such a fashion as to appeal in a striking manner to the world. No other scientist has ever achieved so many brilliant public successes. We must above all things learn from Pasteur's life that after all the chief reason that his reputation advanced so rapidly in the comparatively few years of his active work was in no small measure the fact that he had the wisdom to see that it is to the application of science to practical life that the world in general gives the greatest admiration. There is ever a tendency among scientists to belittle one of their number who attempts to apply to practical life the results of research. In spite of every plea that may be made for pure science it is the application of science to the life of man that has the greatest interest to mankind. As we look through Pasteur's life and study the growth of his wide reputation we shall find that this reputation was largely founded upon the brilliant epochs in his history where he applied to practical subjects the results of the scientific investigation. The advance in his reputation came at those occasions when the public learned of his work because it had been applied to something that interested the world. The homage that the world has given to Pasteur testifies to the value of practical science, testifies to the truth of the position that pure science is of value to man chiefly as it can be applied to facts that influence practical life. While, then, applied science is frequently mentioned with a slight disdain by the modern advanced scientist, it is well to remember that Pasteur, whose reputation as a scientist has perhaps outranked that of any man of the last 50 years, made his reputation and achieved his world-wide fame because he applied to the practical things of life the discoveries revealed to him by his microscope.

The active part of Pasteur's life was so full of investigations in many lines that it is impossible in a brief review that they should receive the weight which they deserve. Only the most important of them can be here mentioned, a selection being made of those upon which his reputation has been chiefly built. Pasteur received an early training as a chemist, and the first work of his life was chemical. Until he had reached about the age of 32 the work he had been doing had been mostly in the line of molecular physics, and certain papers upon the structure of crystals appeared from his pen which even in those early years showed signs of genius. He would have probably made his mark as a chemist had not his attention been turned to a more fruitful field. In 1854 he was appointed Dean of the University of Lille, and it was at this place that his attention was first turned in the direction which subsequently made him famous. A simple incident led him to the study of fermentations in the manufacture of certain chemicals. The crystallization of tartrates had earlier interested him, but now he noticed that tartrate of lime had a tendency to ferment. This fact attracted his attention and led him into observations and experiments upon the nature of the fermentation of tartrates. These experiments demonstrated to his microscope the universal presence of living organisms in the fermenting material. Finding these fermentations universally accompanied by living organisms it appeared to him as probable that the fact must be part of some general law. It was not a pure accident that living organisms were present, but in some way he believed there was a connection between the fermentations and the presence of the organisms. A general law he formulated, and reached the inference that fermentations in general are produced by living organisms, microscopical in size but of very great potency. This conclusion was, of course, a simple inference as yet undemonstrated, but it was the in-

ference which started Pasteur along the line of his experiments in fermentation. It was the guiding star of Pasteur's life. From the moment the inference was drawn until his death this law, that fermentations, putrefactions and all similar chemical changes were produced by the growth of microorganisms, was the basis of every line of investigation which was undertaken by him. Every new problem in his life was attacked by him from this standpoint. The great success of Pasteur's work lay in the fact that his guiding principle was a correct one, his great merit in his wisdom in early adopting it as a law, and his genius in demonstrating it. If he had drawn an inaccurate conclusion from these early experiments he might in time have corrected the error, but we must look upon the fact that he had the wisdom to draw a correct inference from this first work as the foundation of Pasteur's success in life.

Pasteur now became interested in the subject of fermentation. His home was in one of the important seats of fermentative industries, and study of fermentation as a general phenomena at once received his attention, not only from its general interest, but as especially appropriate to his life at Lille. He was thus led away from the line of pure chemistry into biological work, but the change was almost imperceptible. Up to the time when Pasteur began his studies fermentation had been regarded as a chemical phenomenon, and it was natural that a chemist should study it. In the few decades that preceded the work of Pasteur, fermentation had been carefully studied by a number of our chemists and microscopists. While different theories had been advanced, the theory of fermentation, which was almost universally held at the time when Pasteur began his experiments, was that of the chemist Liebig and was a purely chemical theory. In accordance with this theory of Liebig, fermentation is simply the chemical decomposition of bodies produced by the unstable equilibrium of their molecules. This theory held that the molecules of fermentable materials were very unstable and were easily broken to pieces into simpler compounds. The ferment was held to be simply an exciting cause which started this chemical decomposition. Fermentation was thus a purely chemical subject at the time when Pasteur began his studies, and the first work which he attempted was to show that the chemical theory of the scientists of his day should be replaced by the physiological or biological theory which he was convinced from his experiments was the correct one. Upon this task he set himself at once, and by the study of the lactic fermentation of milk, the butyric fermentation of milk, the acetic acid fermentation in the manufacture of vinegar, and by the numerous careful experiments along these various lines which he devised in his laboratory, it required only four or five years for him to undermine completely the chemical theory of Liebig and to put in its place, on a somewhat unstable basis at first, perhaps, the theory that all types of fermentation are organic in their nature and produced by the life of microscopic organisms. Even at this early day we can see his recognition of the value of the practical application of science, for among the very early pieces of work which he performed was the study of the acetic acid fermentation in the making of vinegar, and by a practical application of his results to this industry he developed a vast improvement in the manufacture of vinegar and a great cheapening of the process.

Pasteur had thus made something *his own*, and at this date, in the vicinity of 1860, he became recognized as the exponent of the biological theory of fermentation. From this time he progressed rapidly. The fermentation of wine next claimed his attention. Here was a second fermentative indus-

try in which unexplained difficulties were constantly occurring. He soon found the cause of the various failures of the vintner by which were produced many of the so-called 'diseases of wine.' These diseases he found were all due to the presence of improper micro-organisms during the fermentation instead of the pure fermenting yeasts, and he quickly devised a remedy for them in a process that has subsequently been known by his name as the process of *pasteurization*. This method of preventing the evils involving the heating of wine, was received with great opposition on the ground that the heating injured the flavor. After a great deal of more or less violent disputing on the matter Pasteur arranged for a public test of the question by getting together a large number of experts and convincing them against their will, by ingeniously devised deceits, that they were unable to distinguish between wines that had been pasteurized by his process and wines that had not been subject to heat. Having previously shown that the method of pasteurization was almost a sure remedy against the various diseases, this first public demonstration was thus a brilliant success and at once obtained for his method the acceptance of the vintner.

Meantime he had been giving his attention to the vexed problem of the last two or three centuries, namely, the question of spotaneous generation. Believing, as he did, that all fermentation was caused by micro-organisms, it was a foregone conclusion that he would be an opponent to the view of spontaneous generation. The studies upon fermentation which he had been carrying on, and his accurate methods, trained him especially well for this subject of spontaneous generation, and the experiments which he instituted brought this question into the condition of demonstration. The experiments of early scientists were repeated by him with greater care; many new experiments of his own were devised; the microscope was brought into requisition in new ways. A brilliant conclusion was reached, that by the exercise of sufficient care all traces of life could be avoided and no spontaneous generation ever occurred. It is true that the conclusions of Pasteur were not at once everywhere accepted. In England, particularly, objectors arose who advocated a belief in spontaneous generation, and these objections were not silenced until the English physicist Tyndall took up the experiments that Pasteur had been making and even more satisfactorily reached the same conclusion. But Tyndall's results were only those that Pasteur had reached before, and we recognize to-day that the only basis of the objections that were made to Pasteur's conclusions was the inaccuracy and lack of care with which his opponents performed their experiments. With brilliant rhetoric and loose experimenting, spontaneous generation was still advocated, but the disproof was given by Pasteur in spite of the fact that opposition still arose after the disproof had been reached.

But now Pasteur's attention was to be turned again and in a direction that again changed his whole life and has revolutionized modern medicine. One of the great industries of France is that of the silk-worm raising. About 1850 there appeared upon the silk-worm farms a disease of the silk worm known as pèbrine. This disease spread rapidly from farm to farm, greatly reduced the productions of the silk-worm farms and actually threatened the entire destruction of the silk-worm industry. From 57,000,000 pounds per year in 13 years this industry had fallen to 8,000,000 pounds, all because of the great devastation produced by this disease. Many had been the attempts made to cure it and many the attempts made to discover its cause. Men with a reputation greater than that possessed by Pasteur, at the time, had

attacked the problem and failed. In the year 1865 no remedy had been discovered, no cause was known and the silk-worm industry was threatened with immediate destruction. Pasteur was asked to investigate the question and at first refused to do so. His success in the study of fermentation had opened to him a prosperous career; he knew nothing whatsoever of silk-worm raising, and he was afraid that the investigation, even if successful, would lead him too far from his own chosen line of work. He was, however, over-persuaded and finally accepted the task of investigating pèbrine, little thinking that it was only the continuation of his studies on fermentation and that along the line opened to him by this investigation he was to find his life work and world-wide reputation. Pasteur undertook the investigation of pèbrine already prepared for his discoveries, for living micro-organisms were for him potent agents in nature. He very soon discovered that the cause of the disease was a microscopic organism living in the moth. He was not the first to discover this organism, for others had seen it and described it. That Pasteur succeeded where others failed was due to the fact of his belief in the powers of the microscopic world. Others regarded these organisms as of no importance, but Pasteur had become so imbued by his study of fermentation with the important agency of microscopic organisms that the very first question that he asked was whether living bodies were not the cause of the disease that he had been set to investigate. If organisms could produce fermentations in dead material why might they not produce disease in living creatures? The result of his work here we need not dwell upon. It was a brilliant success. It demonstrated that the disease was caused by the organisms and it devised a remedy against the trouble by simply breeding from healthy moths. The world laughed at him; those interested in the silk worm industry refused to adopt his methods as those of a fanatical microscopist, and too simple. He met at first with nothing but opposition, but the man arose to the occasion and so sure was he that he was right that he again arranged for a public demonstration. An abandoned silk-worm farm was put into his hands and, although at the time an invalid and unable to travel by ordinary means, he had himself transported across France and personally directed the work on this silk-worm farm, although he was unable to do anything himself. It is not, perhaps, generally known that from this time to his death Pasteur was partially paralyzed and unable to perform the work of his own experiments. There is something truly pathetic and dramatic as we think of him, an invalid, simply capable of directing others in their work, and yet fired with the belief that he was right and with the determination to convince the world that he was right. Again Pasteur's genius demonstrated itself and, by using his simple remedy, in a short time this silk worm farm, abandoned because of the presence of the disease, was restored to a condition in which it was one of the best paying silk-worm farms in France. The disease was practically eradicated from it. With a bound Pasteur's reputation spread throughout France and the world. The silk-worm industry in France began to adopt his methods at once and rapidly assumed its old condition of prosperity. From now on the Frenchmen were ready to accept almost anything that Pasteur would say. He had saved them their beloved silk-worm industry and had been the means of saving to the peasants of France a sum of money almost beyond belief.

The next important work in Pasteur's life was his investigations upon the subject of the fermentations of beer. The Franco-Prussian war and its results had deprived

the French people of their beer makers, who had been largely German, and when the French people began to make their own beer they found themselves for awhile in difficulties. In spite of careful methods various imperfections in fermentations were of frequent occurrence. By this time the French public had become confident in Pasteur's abilities, and it was only natural that he should be requested to find the solution for this puzzle. As usual, success attended his efforts. His microscope soon showed him that the trouble was due to the use of impure yeasts. The brewer's yeast was liable to be mixed with various species of bacteria as well as improper species of yeasts, and his genius soon showed methods of removing the difficulties and bringing the fermentative industry into a condition of uniformity. Upon the basis of these experiments has been founded the whole of our modern brewing industries. The large brewery of to-day is impossible without the microscope, and to the stimulus given by these discoveries of Pasteur has been due the great centralization of brewing.

The next problem that attracted the attention of Pasteur was the dreaded anthrax. For several years this devastating disease had been the subject of scientific investigation. Already its connection with micro-organisms had been made probable and indeed had been demonstrated. Many problems had been solved, but many still remain to be solved in connection with this pestilence of the agriculturist. As usual Pasteur began at the beginning taking nothing for granted, even of the facts that had been essentially demonstrated. His experiments resulted in a more complete demonstration of the relation between the anthrax bacillus and the disease, showed the method of action of the germ, demonstrated the source from which it was frequently derived by cattle, differentiated between this disease and one or two others closely resembling it among animals, disproved all of the objections that had been raised by those who disbelieved in the causal nature of the bacilli, and, in short, brought this subject upon the same sure foundation as that of pèbrine which he had so triumphantly solved ten years before. Nor was this all. The greatest discovery of his life was to follow. To Pasteur's peculiar trait of mind it was not enough to discover the cause without searching for the remedy. It was the *practical* question which appealed to him. Pasteur recognized the fact that in the human race one attack of an infectious disease frequently renders an individual immune against a second attack. He also remembered that protection against small pox had been known to be produced by vaccination. Acting upon these suggestions the question arose in his mind whether it were not possible to give to domestic animals, subject to this devastating disease, a milder type of the disease in question, from which they should readily recover, but which would give them immunity against a second attack. The principle was a new one and outlined a new, bold plunge into the mysteries of nature. It was not, however, in the investigations of anthrax that the remedy first suggested itself, but rather in a side investigation upon the subject of another germ disease known as fowl cholera. Every one is familiar with the results. He discovered a method of rendering the invading organisms of fowl cholera so impaired in their action as to be unable to produce death, giving rise, on the contrary, simply to a slight indisposition; but demonstration soon showed him that this slight indisposition was followed by immunity against the more severe disease. To anthrax he turned the same line of investigation, and after patient, laborious search discovered a means of rendering the anthrax

germ impaired in its vigor. His preliminary experiments convinced him that he had achieved success, and then came one of those dramatic public exhibitions in which Pasteur so delighted and which have so impressed the world. Almost before the public had learned that he had obtained a possible method of preventing this dread disease among agriculturists, Pasteur made arrangements for a public test of his method, and in the presence of an audience of some 200 experts made up of physicians, veterinarians, Senators, prefects, farmers, members of the French Academy and others of high standing, he demonstrated by a simple experiment, lasting about a week, that he could with unerring certainty prevent cattle from acquiring anthrax; that he could give to them a practically absolute immunity against this almost surely fatal disease by infecting them with a very mild indisposition a few days before. The effect upon the audience was electrical and their enthusiasm knew no bounds. Pasteur's experiments spread at once over the world, and from this further practical application of his scientific research his reputation made another advance. His anthrax vaccine was distributed through the civilized world, was used by grazing communities everywhere, and it has been thought to have saved the life of hundreds of thousands of cattle. The greatness of this discovery can hardly be appreciated to-day. It was a logical discovery of a new method of meeting disease. While other even more valuable discoveries in the same line have followed and are still to follow, none can equal in significance this first application of the studies of the microscope to the treatment of disease.

Following the work upon anthrax various other lines of bacteriological research connected with diseases of animals attracted his attention and demanded his time. It It was not, however, until he had attacked the problem of the most dreaded of all human diseases, hydrophobia, that he again attracted the public eye. His experiments upon hydrophobia were, perhaps, the boldest in the line of experimentation that had ever occurred, for here for the first time in history laboratory experiments were transferred to the human being. Hydrophobia had fascinated Pasteur for a long time. Experimental work had shown him that the disease was not a purely nervous excitation, as had been claimed, but that there was an actual disease under this name. Experiments showed him further that the disease bears every similarity to infectious germ diseases, although neither he nor anyone else, even to the present day, have succeeded in demonstrating the organism which produces the diseases. Experiments upon dogs and rabbits in his laboratory followed each other rapidly,and with his usual genius he devised many a method of hastening the experiments and of rapidly reaching results which would normally take months. His success with other diseases made him ambitious also to find a method of preventing this disease, and, while the methods which he had used in fowl cholera and anthrax proved useless in the case of hydrophobia, the same general line of work led him finally to a method of inoculating animals which rendered them immune against this disease. Not only so, but the same method when applied in a slightly different way was found to be efficacious in warding off the disease in an animal which had been previously inoculated therewith. He found himself able with certainty to inoculate an animal with hydrophobia and then, by treating him with the various subdermic injections which he had devised, prevent the appearance of the disease which would have otherwise inevitably occurred. Laboratory experiments were a success, and next the bold step was taken of applying to mankind laboratory methods, which had been hither-

to tried upon animals alone. A youth who had been severely bitten by an unquestionably rabid dog was brought to him at his laboratory. The youth's life was despaired of by the physicians, inasmuch as with certainty he would develop hydrophobia. Under the circumstances Pasteur felt justified in trying upon this youth the experiments that had succeeded with dogs and rabbits. The experiment so far as could be demonstrated was a success. The youth failed to develop this disease. But for a final demonstration that his methods were successful was required a long series of public experiments which were not to be obtained by any one dramatic incident. To obtain such testimony no means appeared to be possible except to announce to the public the discovery of a method of preventing hydrophobia. Such an announcement was made by Pasteur. The public had such unlimited confidence in the man that they at once accepted the conclusion as correct. Certain it is that no one else could have taken the public into his experiments, but his uninterrupted success in previous years gave all a belief that he had made no mistake here. Opportunities for experiment began to multiply, and scores and then hundred of individuals who had been bitten by animals, either rabid or supposed to be rabid, flocked to the laboratory of Pasteur to be treated by his method. The experiments thus begun have continued for eight years, and even yet can hardly be considered as concluded. The opinion of the public, and especially of the medical world, has vibrated from one side to the other. At first Pasteur's conclusions were accepted as probable simply on the basis of the great reputation of the man, and the fact that Pasteur made so few mistakes. Later, flying to the other extreme, the whole efficacy of the method as practiced by Pasteur was doubted. Most violent opposition arose, and it is thought that this opposition contributed to undermine Pasteur's health and check his active life. Later again the world became slowly convinced, by the accumulating testimony in his Institute, that here too no mistake had been made. At the present time there is hardly a question that Pasteur's methods, even in the case of hydrophobia, have demonstrated themselves as successful. While statistics are a very uncertain kind of evidence, one cannot read of the success which has attended the inoculation in Pasteur's Institute for eight years without being convinced that Pasteur's methods are correct. In his Institute have been treated several thousands of cases of persons bitten by animals supposed to have been rabid, and among those that have been treated the number of deaths has only been a trifle over one per cent. With this exceptionally small percentage, even after we say everything possible as to the uncertainty of statistics, we can hardly question that truth underlies these methods, and that Pasteur's last great work was as successful as those of his earlier years.

This work upon hydrophobia was the last piece of work which we have directly from Pasteur's own personality. A Pasteur Institute was established, and from that Institute has come, and is still coming, a series of investigations along the lines that Pasteur began, which are yearly adding not only to our scientific knowledge, but to our practical method of dealing with disease. While Pasteur's name is no longer attached to these individual researches, the master's hand gave the inspiration for them all. For several years the experiments have all been in the hands of his assistants. While we have looked upon them as his assistants, we must recognize them as independent and as having achieved their own reputation, but nevertheless, we must feel that the work that has come from Pasteur's Institute, and that will for a number of years be given to the

world from that source, must be directly or indirectly attributed to the inspiration of the master for whom the Institute was founded.

The world's debt to Pasteur we cannot estimate. His financial gifts we can realize, when we remember that he saved the silk-worm industry, that he taught the vintners how to make wine, that he established the fermentative industry the world over, and that he gave to the agriculturists a method of preventing anthrax, we can see that the financial value of his life to the world was far beyond that of any other person that ever lived. The debt of theoretical science to him is equally great, though not measurable in any terms. He disclosed a new world; he discovered a new series of phenomena taking place below the realm of human vision and he opened to the world a new field of science. To medicine again his gifts were beyond measure. To him more than any other is due the demonstration of the germ nature of disease, and to his work we owe our hopes for medical science in the future. The practice of medicine has been almost purely empirical. To-day we are hoping that it is gradually becoming a matter of science. As we know the causes so we can search for the remedies against disease, and to Pasteur is due the first attempt to place medicine upon a scientific basis. Surgery has already become a science, and this too is indirectly attributable to him. While modern surgical methods were developed by Lister, the methods of Lister were devised as the result of the study of Pasteur's work in fermentation. Pasteur has opened to us a new world and given to us a new science, has established upon a firm basis a science of medicine and a science of surgery, and has added to the financial stores of the world accumulations of great magnitude. It was all done by slow work. The field was not a new one, for already investigators had made inroads therein, but no one with anything like certainty and accuracy. For years it was Pasteur alone who was capable of investigating bacteriologically with anything like a certainty of successful issues. Bacteriological methods were too difficult to be handled by anything but a master. To-day it is true the methods have been so simplified that far less genius is required to handle them, and to-day the bacteriologist has multiplied in every direction. But at the time when Pasteur was the pioneer the methods were so difficult as to be beyond the reach of any except those of the greatest genius. Nor can we measure our debt to Pasteur by his own work. This, indeed, was great, but our debt to him must be also measured by the work of followers who were inspired by him. In France, in England, in Germany, in America, we find the study into this realm of the microscope inspired by the long, laborious and successful work of the French master. Even in the latest achievement, the use of antitoxine, we have the direct result of Pasteur's life. Where one leads others may follow. For a long time Pasteur stood alone, and it was only work that he had done that could be looked upon as demonstrated. Little by little, however, others came into the line of research, and when to-day Pasteur is taken from the field of activity there are many capable of carrying on his work. No man that France has created is so worthy of her pride. No man who has lived in history has done so much for humanity. No one who has lived will be remembered by posterity as having had such an influence upon the world in the way of discovering facts which advance the health and prosperity of mankind. But, perhaps, the proudest achievement he attained, viewed from the standpoint of a scientist, was earning the right to the claim that '*Pasteur never makes mistakes.*'

H. W. Conn.

Wesleyan University.

PASTEUR AS ILLUSTRATION OF MODERN SCIENCE.

APART from the inspiring promises and hopes of high science, every one should realize clearly the direct practical value to be derived in the daily intercourse of each with nature, from a correct knowledge, of even the most elementary, of the laws of this world in which we are striving to live happily.

It is true that the advocates of science-teaching can adduce other, perhaps far nobler grounds, in pointing out the high and symmetrical development, which the study of science gives to the human intellect and the unfailing well-spring of pure pleasure which it affords.

But many of the older men now in power, having never had any accurate training in science, can scarcely appreciate such arguments, and if capable of being reached at all, it must be by proofs the most cogent of the unfailing utility of elementary science, and the stupendous wealth producing power of high science.

We cannot any longer afford to let children grow up ignorant of all that is going on around us in this beautiful world, without learning to use eyes and reasoning powers, because their parents may know nothing accurately of the laws of physical, but above all, of mental health.

Fundamental principles and their commoner applications must now be universally taught, if only to let every one realize how now our modern science stands ready to aid, to save, to satisfy, endangered or craving bodies or minds.

Nor is it only to the mature mind that the study of science is a pleasure. It has been well said that nothing is more beautifully characteristic of young children than the desire to know the why and wherefore of everything they see. This natural spirit of inquiry needs only proper direction and fostering care to give us great scientists, men who, like Pasteur, confer uncounted millions of actual physical wealth on the country or state so fortunate as to be honored by their presence.

The great practical difficulty, however, in regard to giving science the place every one is beginning to see belongs to it, in elementary as well as advanced education, is that it requires for success, teachers of far higher order than those usually employed to drum into young heads the dry old school routine. No one can teach science who does not know it. And for a teacher to have the true informing spirit to vivify his book knowledge, it is found almost uniformly essential that he should have been in direct personal contact with some one of those great men whose joy it is to be able to advance the age in which they live, and lead on mankind to unexpected victories in the progressive conquest of the universe.

To get our brightest young people so to qualify themselves, it is needful they should understand the surpassing dignity of science and science teaching; that in fact, of late years, not only surprising discoveries are coming on in crowds, but that whole new sciences of world-remaking power are springing into existence around us. As one illustration from many, take what has been called bacteriology.

It is only a little more than 20 years ago that the publication of Pasteur's papers on alcoholic fermentation gave the first sound basis for the idea that fermentation was caused by a micro-organism.

It is now demonstrated that *all* fermentations of this class are due to the development of micro-organisms, and that bacteria are most important factors in nature, being the chief agents by which the complex organic constituents of plants and animals are brought back to simple forms capable of serving again as food for plants.

Following closely on Pasteur's early publications, and as a direct result of them, we

have the great revolution in surgery brought about by Sir Joseph Lister, which has enlarged the whole scope of the science, and is daily saving hundreds of lives.

Besides the vast increase in our knowledge of the mode of spead of infective disease, successful experiments have been carried on by Pasteur on the attenuation of virus and the conversion of virulent micro-organisms into useful vaccines.

And perhaps one could not choose a more readily understood illustration of the wealth conferred on his whole nation by a man of science than is furnished by a recapitulation of some of the things accomplished by Pasteur. Having discovered exactly what fermentation is, he was able, by a few simple directions, to almost entirely put an end to the spoiling of beer by secondary fermentation and the souring of wines by the transformation of alcohol into acid.

This sounds rather unimportant, but some idea of its commercial value may be obtained when it is remembered that there are about 45 departments of France that make wine, and there was a known loss yearly of wine to the extent of one million seven hundred thousand francs in four departments. Since Pasteur's method has been applied, there has been saved of this loss at least one million five hundred thousand francs annually. This is for four departments. As there are in France about 45 departments that make wine, you may approximately estimate the stupendous saving.

Again the farmers and stockmen of France were visited by a terrible and increasing cattle plague, the malignant pustule, or black quarter of cattle and sheep, which killed annually thousands of horses and oxen and hundreds of thousands of sheep. There seemed no hope for them. But Pasteur found by a series of researches not only that this disease was caused by a specific minute organism, but that he could save the animals from contagion by inoculating them with attenuated germs obtained by artificial cultivations made in special liquids.

The figures from the official statement indicating the ravages made by this disease in France alone for the years 1882 and 1883 are 2,196 horses, 62,107 oxen, 538,245 sheep.

When we learn that the average mortality was reduced by Pasteur's inoculations in the proportion of 10 to 1 for sheep, and 15 to 1 for oxen, cows and horses, some idea may be grasped of his vast and continuous gift of wealth to his country in actual solid meat—beef and mutton.

Again, another disease has reduced the silk-worm industry to a most deplorable condition. In three departments in the center of France, after the silk-worm disease had attacked the factories, the product yielded a value of less than one million five hundred thousand francs.

But Pasteur came to the rescue, discovered the micro-organism, conquered it, and since the regulations laid down by him have been applied, the average value per annum, calculated on five years, in those departments has risen to more than twenty-two million francs.

After such facts as that, who can wonder at those sentences from Huxley: "I weigh my words when I say that if the nation could purchase a potential Watt, or Davy, or Farraday, at the cost of a hundred thousand pounds down, he would be dirt cheap at the money. It is a mere commonplace and everyday piece of knowledge, that what these three men did has produced untold millions of wealth, in the narrowest economical sense of the word."

But let no one suppose that these men or any other of the immortal scientists would have been satisfied even by producing untold millions of wealth. They all had higher aims and made higher achievements.

From such men and from science comes

a progressive betterment of human character, the final, the most precious result of evolution on this earth.

GEORGE BRUCE HALSTED.
AUSTIN, TEXAS.

DETERMINATION OF THE CONSTANTS OF THE DIURNAL NUTATION.

(1) In the *Annuaire de l'Observatoire Royal de Belgique* for 1894, I gave the following results deduced from Gyldén's observations of the latitude of Pulkova:

Let κ = constant of annual aberration,
κ' = *reduced* constant of systematical aberration,

i. e., *projected on the equator*, which I derived from my terms of the second order which arise from the combination of annual and systematical aberrations.*

$\tilde{a}$ = parallax of Polaris;
ν = Peters's constant of nutation 9″.2235;
n = the correction of this constant;
ν' = Peters's constant of the term cos 2 ⊙ : 0″.555;
n' = its correction;
ν = the constant of the diurnal nutation;
L = the longitude of the *first* meridian,

i. e., the meridian which passes through the axis of the moment of inertia A of the solid crust of the globe.

Applying my formula, M. Byl, astronomer adjunct at the Royal Observatory of Belgium, has found

$\tilde{a} = 20''.408$. $\kappa' = 39''.$ $\omega = 0''.0546$.
$n = 0''.003$. $n' = -0''.0444$.
$\nu = 0''.0665$. L = 12h 0m E. from Pulkova.

Illness has prevented M. Byl from coördinating his calculations, and I was compelled to make a new determination of both the last constants for the next volume of the *Annales de l'Observatoire Royal de Belgique*.

(2) My purpose was to make use of the excellent series of observations of the Polaris in $\mathcal{A}$ made at Dorpat by F. W. Struve, a series which had led me to conclude that the Eulerian period of 305 days was too short.*

In order to eliminate the variations of latitude, I have only used half of the sum of $\mathcal{A}$ observed at consecutive upper and lower transits. The laborious calculation of the whole series has given me unexpected results: $\nu = 0''.17$, twice or threefold too great; $L = 12^h\ 10^m$ E. from Pulkova, good result; $n' = +\ 0^j.045$, which is in complete discordance with the value $n' = -0''.0444$ deduced from Nyrén's observations, and moreover, theoretically inadmissible. In seeking the cause of these unlooked-for results, I found that an error of sign I had noted down some years ago and considered as a simple typographical error has been used by Peters in all his reductions of Struve's observations. In his formulæ (p. 13 of *Numerus Constans nutationes*) he wrote with +, instead of —, the terms of nutation in 2 ⊙, and calculated his reductions with this erroneous sign.

All my work had to be done over again, as will be the case for Peters's determination of the constant of nutation.

In order to eliminate this serious error I used Struve's residuals, corrected by increasing by 0.″2 the Delambre's constant he had used for his reductions, and to avoid the other errors of reduction I have formed the differences between successive pairs of observations chosen so that the coefficients Σ_1 and Σ_2 were sufficiently different in both pairs.

(3) The diurnal nutation in $\mathcal{A}$ is in the meridian

$$\Delta a = -tg\ \delta\ (\xi\ \Sigma_2 + \eta\ \Sigma_1),$$

where $\nu = \nu \sin(2\,\mathrm{L} + a)$, $\eta = \nu \cos(2\,L + a)$; we may write

$$\Delta a = x\ \Sigma_2 + y\ \Sigma_1 = ax + by.$$

The principal terms I have used for the calculation of a (Σ_2) and b (Σ_1) are

* Catéchisme correct d'astronomie sphérique (Memorie della Pontificia Accademia dei nuovi Lincei, Roma. Vol. IX.), and Annuaire de l'Observatoire Royal de Belgique pour 1894, p. 346.

* Annuaire de l'Observatoire Royal de Belgique pour 1891.

$$a = -0.18 \sin \Omega + 0.39 \sin 2\odot + 0.89 \sin 2\mathbb{C} + 0.18 \sin (2\mathbb{C} - \Omega).$$

$$b = -1.155 - 0.134 \cos \Omega + 0.36 \cos 2\odot + 0.82 \cos 2\mathbb{C} + 0.14 \cos (2\mathbb{C} - \Omega).$$

writing, with Peters,

$\pm v$ = correction for the position (E or W) of the circle; w = correction of the mean $\mathfrak{R}$ of Polaris, and remembering that the correction of the terms in $2\odot$ has been eliminated by taking the difference between two pairs of observations, we have only the equation of condition

$$ax + by \pm v + w + n = o;$$

the unity of the residual, n, is the second of time.

(4) By taking the differences between the equations formed for such a pair of upper and lower culminations, two by two, it is clear that we shall obtain the simpler equation

$$(a_2 - a_1)\, x_2 + (b_2 - b_1)\, y + n_2 - n_1, = o,$$

which we write

$$ax + by + n = o.$$

The following table gives the values of p weights of the two equations used; a, b, n, n', multiplied by 100; the point after a number signifies 0.5. n' is the new residual obtained after the substitution, in each equation, of the values found for x and y.

	p.	a.	b.	n.	n'
1822. Nov. 5 and 12	(1.4)	—182	— 10	—87	—88
1823. May 6 and 16	(1.2)	—138	+ 77	6	— 5
" 16 and 19	(1.2)	—110	— 82	33	45
" 19 and 21	(2.3)	— 26	+ 56	—36	—45
" 21 and 30	(3)	— 29	145	14	8
May 30 & June 2	(3.4)	— 84	47	—10	4
Sept. 8 and 11	(1.2)	— 53	120	2	—17
Oct. 9 and 11	(1.2)	58	— 12	15	18
" 11 and 13	(2.3)	63	— 52	—34	—25
" 13 and 28	(3)	— 28	— 39	—37	—32
" 28 & Nov. 8	(2.3)	— 17	80	37	24
Nov. 8 and 14	(1)	63	50	—59	—66
" 14 and 26	(1.2)	—132	— 96	23	37
" 26 & Dec. 8	(1.2)	— 88	— 38	—15	— 8
1824, Apr. 6 and 11	(1)	—102	—175	—90	—63
" 11 and 23	(1.3)	81	149	+79	+56
" 23 and May 1	(2.3)	— 76	+ 58	—30	—40
May 1 and 3	(1.2)	55	— 10	72	74
" 21 and 22	(2.4)	— 72	— 15	—25	—24
" 22 and 28	(2.3)	— 6	—199	—23	— 1
" 28 & June 2	(1.3)	— 96	—146	—15	10
June 2 and 7	(1)	— 33	— 37	43	48
" 7 and 9	(1)	—119	114	64	44
" 9 and 12	(1.2)	144	25	— 7	— 9
" 12 and 17	(1.2)	— 5	—136	15	37
" 17 and 22	(1.4)	—121	62	—19	—30
Sept. 22 and 25	(2)	—100	70	— 7	—20
" 29 & Oct. 3	(2)	+156	— 16	—27	—22
Oct. 18 and 22	(1.2)	—142	65	26	14
Nov. 20 & Dec. 5	(1.2)	53	29	—61	65
Dec. 5 and 19	(2)	62	17	—41	43
1825. Mar. 15 and 17	(2.3)	— 54	— 61	—33	24
" 17 and 20	(2.3)	—102	57	2	— 9
" 20 & April 1	(2.3)	45	— 38	51	58
April 1 and 8	(2)	12	—116	70	51
May 1 and 7	(1.3)	147	44	—82	87
" 7 and 10	(1.3)	3	— 52	—18	—10
" 10 and 18	(1.4)	—125	84	2	—13
June 1 and 3	(3)	— 59	— 40	27	+33
Oct. 2 and 5	(1.3)	— 30	—110	—49	—32
" 3 and 4	(1.2)	35	— 9	11	+13
" 22 & Nov. 7	(1.2)	— 62	— 0	34	+33

(5) From this system we have deduced the normal equations

$$3882.5\, x + 142.6\, y - 27.6 = 0$$
$$142.6 + 3801.7 + 613.9 = 0,$$

which gives

$$x = 0^{\prime\prime}.013 \pm 0.0044$$
$$y = 0.162 \pm 0.0049,$$

Where we deduce from

$$x = -\nu\, tg\, \delta \sin (2L + a)$$
$$y = -\nu\, tg\, \delta \cos (2L + a)$$

$\nu = 0.''070 \pm 0.''0019.$

$2L + a = 357° 20' \pm 46'.$

$2L = 342° 52' \pm 46'.$

$L = 11^h\ 25^m.7$ E. from Dorpat
$= 11^h\ 11^m$ E. from Pulkova.

The agreement between the constants deduced from Gyldén's observations of Polaris in Declination $\nu = 0.''0665$, $L = 12^h\ 0^m$ E. from Pulkova, and from Struve's observations in $\mathfrak{R}$, together with all the determinations I have made of these constants since 1888,* and with the smallness of the

* Annuaire de l'Observatoire Royal de Belgique, 1888–1894.

probable errors, is an irrefutable proof of the diurnal nutation.

The observations of Peters on the latitude of Pulkova had given me* $\nu = 0.''17$, $L = 11^h\ 58^m$ E. from Pulkova. But these observations are not nearly so precise as Gyldén's and have given a constant much too great.

(6) In order to corroborate my own conviction, I tested the determination of these constants by means of a short series of observations, treated like the preceding of Struve. This series is from Preuss' observations (1838, May 18–June 29).

In this case again the equation will be

$$ax + by \pm v + w + n = 0.$$

The following table gives the values of p, a, b, n. For such a short series we could not introduce the correction of the term $\sin 2\odot$, and we can expect a much too great value for ν. Our criterion will also be the longitude L.

1838	p	a	b	± 1	n (in sec. of arc)
May 19	4	0.56	—0.55	+1	— 3.''14
28	2	—0.53	—1.51	—1	— 5.94
May 29, June 1	2	—0.33	—1.04	—1	—10.6
June 7	4	0.79	—2.34	—1	— 1.67
9	3	—0.0167	—2.64	—1	+ 3.03
11	4	—0.742	—2.40	—1	— 7.14
June 13	4	—0.713	—1.19	—1	— 8.64
19	1	1.01	—1.96	+1	—15.0
27	3	—0.443	—0.96	—1	— 4.92
29	4	—0.193	—0.70	+1	—0.113

(7) From this system we have deduced the normal equations

— 3.25 x	—46.6 y	— 7 v	+31 w	—108.03=o
5.60	+26.9	+31	— 7	+ 79.55
10.46	+ 4.01	+ 5.6	— 3.25	+ 24.92
4.01	+88.0	+26.9	—46.58	+ 82.22

whence

$x = 5''.6$ $\quad y = 15''.4$ $\quad v = -11''.3$ $\quad w = 20''.7$

All these values are very great, which arises from the size of the residuals. It is to be noticed, however, that the signs of v, u, w are the same as those deduced by Peters from all the observations of Preuss.

From x and y we deduce $tg\ (2L + a)$, whence $L = 12^h\ 8^m$ E. from Dorpat, which agrees very well with all the preceding determinations.

(8) I will now give still another remarkable example of deductions, and one which shows the diurnal character of this nutation. For this case I have given the formulæ referred to the equator, which dispense with the calculation of the functions Σ_2 and Σ_1†. From these formulæ I have deduced the following expressions for the diurnal nutation in obliquity, $\Delta\theta$, and in longitude $\Delta\lambda$:

$$\Delta\theta = y\left\{(\Sigma_1 \sin\varsigma'_1 - \varsigma_1 \sin R'_1) + 2.18\,(\Sigma_2 \sin\varsigma'_2 - \varsigma_2 \sin R'_2)\right\}$$
$$+ x\left\{(\Sigma_1 \cos\varsigma'_1 - \varsigma_1 \cos R'_1) + 2.18\,(\Sigma_2 \cos\varsigma'_2 - \varsigma_2 \sin R'_2)\right\}$$
$$\sin\theta\,\Delta\lambda = x\left\{(\Sigma_1 \sin\varsigma'_1 - \varsigma_1 \sin R'_1) + 2.18\,(\Sigma_2 \sin\varsigma'_2 - \varsigma_2 \sin R'_2)\right\}$$
$$- y\left\{(\Sigma_1 \cos\varsigma'_1 - \varsigma_1 \cos R'_1) + 2.18\,(\Sigma_2 \cos\varsigma'_2 - \varsigma_2 \sin R'_2)\right\}$$

in which the index 1 is referred to the Sun, 2 to the Moon. The notations are the following:

$$\Sigma = (1 + \theta_2)\sin(1 - \tfrac{1}{2}\varsigma_2)\,A\,t, \quad \varsigma = (1 + S_2)\sin(1 - \tfrac{1}{2}\varepsilon_1)\,\Delta t,$$

Δt being the interval between the two observations.

$$\theta_2 = \tfrac{2}{3}\iota_2 - \frac{C-A}{A}, \quad S_2 = \tfrac{3}{2}\varsigma_2 - \frac{C-A}{A}\,1\,\frac{C-A}{A} = 0.00328.$$

$$T_2 = a_2 + 2d_2\ ;\ \tau_2 = a_2 - 2d_2,$$

* Ibid., 1894.

† *Theory of the diurnal, annual and secular motions of the axis of the earth.* Brussels. 1884.

a_2 and d_2 denoting $\frac{a_1}{n}$ and $\frac{d_1}{n}$, a_1 and d_1 the mean motion of the perturbing body (Sun or Moon) in Æ and D, n the diurnal motion of the Earth.

$\varsigma' = S - 2\tau$, $R' = R - 2\tau$, τ being the mean between the sidereal times of both observations, $S = A + 2D$. $R = A - 2D$.

$A =$ Æ, $D =$ Decl. of the perturbing body, calculated for the time τ.

$$x = \nu \sin 2L', \quad y = \nu \cos 2L', \quad L' = L + \tau,$$

whence $tg\, 2L' = \frac{x}{y}$; $\nu = \frac{x}{\sin 2L'}$; $L = L' - \tau$.

The observations give $\Delta\alpha$ and $\Delta\delta$, differences between the residuals $n\alpha$ and $n\delta$ obtained by each observation; whence we deduce by means of the known formulæ of transformation $\Delta\theta$ and $\Delta\lambda$.

(9) The following table gives all the elements of the calculation, extracted from the "*Annales de l'observatoire de Kiev* (5 min. *W.* from Pulkova), Vol. I., Observations de la Polaris sime par Fabritius." All the calculations were kindly made by M. Niesten, astronomer at the Royal Observatory of Belgium.

Datum.	τ	Δt	$\Delta\alpha$	$\Delta\delta$	by $\Delta\theta$	by $\Delta\lambda$	S_1	R_1	S_2	R_2
	h m	h m								
1879. June 17	17 25	4 53.5			0.4975 n	0.4737	132° 39′	39° 3′	111° 31′	11° 35′.5
" 20	17 45	4 9			9.8754 n	0.0340	135 55.5	42 7	150 47	53 58.5
" 21	18 33.5	2 31			9.9921	0.0590 n	136 50	43 2	158 59	74 0
" 22	19 49	0 53			9.6383	9.6798 n	138 5	44 19.5	164 19.5	95 44
" 25	17 22.5	4 52			9.5111	9.5828 n	141 4	67 3	169 3	153 19.5
Jul. 1	19 41	1 40.5			9.5488	9.8870 n	146 42	54 18	199 44.5	303 15.5
" 4	18 4	3 45			0.1130	0.1801 n	149 16	57 45.5	255 9	339 28.5
" 7	20 31	1 13			0.2992	0.3666 n	151 35	61 47	325 46	348 41
Aug. 9	20 8.5	4 51			9.8052	9.8693	170 52	107 38.5	82 5	358 36
" 17	20 20	5 28			0.3256	0.3920 n	173 34	120 5	167 31	124 9.5
" 18	21 17	7 26			0.1224	0.1884	173 50.5	121 43	168 51	149 48.5

Whence the following equations, where the numbers are expressed in logarithms:

					ν	$2L^1$	L^1	L
					"	° ′	h m	h m
17 June	1879.	1.3529 y	−0.1658 x	=0.4975 n	0.122	135.7	4 30	11 5
		0.5659 y	+1.7530 x	=0.4737				
20 "	"	1.2713 y	+0.7353 x	=9.8754 n	0.044	127.18	4 14.5	10 29.5
		−1.1354 y	+1.6713 x	=0.0340				
21 "	"	1.0142 y	−0.2424 x	=9.9921	0.104	132.20	4 24.5	9 51
		0.6425 y	+1.4143 x	=0.0590 n				
22 "	"	0.4661 y	−0.2054 x	=9.6383	0.102	151.24	5 3	9 14
		0.6055 y	+0.8662 x	=9.6798 n				
25 "	"	0.6698 y	+9.9484 x	=9.5111	0.076	127.32	4 15	10 52.5
		−0.3485 y	+1.0699 x	=9.5828 n				
1 June–Oct.	"	0.3477 y	−0.8464 x	=9.5488	0.063	154.18	5 8.5	9 27.5
		1.2464 y	+0.7478 x	=9.8870 n				
4 "	"	1.1805 y	+0.7660 x	=0.1130	0.119	201.00	6 42	12 38
		−1.1661 y	+1.5806 x	=0.1801 n				
7 "	"	−9.9292 y	+0.3691 x	=0.2992	0.095	166.16	5 32.5	9 1.5
		−0.7693 y	−0.3293 x	=0.3666 n				
9 Aug.	"	−1.9162 y	−1.1526 x	=9.8052	0.050	142.56	4 45.5	8 37
		−0.3163 y	+1.5527 x	=9.8693				
17 "	"	1.0950 y	−0.4917 x	=0.3256	0.114	167.25	5 45	9 25
		0.8918 y	+1.4951 x	=0.3920 n				
18 "	"	0.9663 y	−0.8181 x	=0.1224	0.128	180.30	6 1	8 44
		1.2182 y	+1.3664 x	=0.1884				
				Mean,	0.091			g 58.6

The agreement between these various determinations is truly most satisfactory, so much the more so as many of them (the 4th, 6th and 8th), are from observations whose interval does not reach two hours.

It is sufficient to establish, not the values of the constants (the number of observations is too small), but the existence of diurnal nutations.

(10) In conclusion, I believe astronomers

may at once introduce in their reductions my expressions of the diurnal nutation, employing the constants:

$$\nu = 0''.07,\ L_o = 1^h.5 \text{ E. from Greenwich.}$$

My formulæ are, *in the meridian*:

$$\Delta a = -tg\,\delta\,(\eta\,\Sigma, + \xi\,\Sigma_2).$$
$$\Delta\delta = -\xi\,\Sigma_1 + \eta\,\Sigma_2$$
$$\xi = \nu \sin(2L + a);\ \eta = \nu\cos(2L + a);$$
$$L = L_o + \lambda$$

λ denoting the longitude of the observatory, W. from Greenwich.

$$\Sigma_1 = -1.155 - 0.134\cos\Omega + 0.36\cos 2\odot + 0.82\cos 2\mathbb{C} + 0.14\cos(2\mathbb{C} - \Omega) - 0.13\cos(\mathbb{C} - \Gamma')$$
$$\Sigma_2 = -0.18\sin\Omega + 0.39\sin 2\odot + 0.89\sin 2\mathbb{C} + 0.18\sin(2\mathbb{C} - \Omega) + 0.07\sin(3\mathbb{C} - \Gamma') + 0.07\sin(\mathbb{C} - \Gamma'),$$

where the arguments are true longitudes.*

F. FOLIE,
DIRECTEUR DE L'OBSERVATOIRE ROYAL DE BELGIQUE.

CURRENT NOTES ON PHYSIOGRAPHY (XVII.).

THE LABRADOR PENINSULA.

THE last few years have added much to our knowledge of this inhospitable region. Besides the Bowdoin expedition to the Grand falls of the Hamilton river, Low and Eaton, of the Canadian Geological Survey, traversed the interior by several routes (London Geogr. Jour., June, 1895, 513–533, map) and Bell, of the same survey, gives an excellent summary of his own explorations and of all available material (Scot. Geogr. Mag., July, 1895, 335–361, map). Labrador is a moderately elevated plateau, averaging 1,800 feet above the sea, of Archæan rocks; hilly, interspersed with many lakes and swamps, and having a surface of bare rocks, alternating with numerous and large boulders and other glacial debris. Mountains rise along the northeast, north and northwest border, the loftiest being the first named, with summits reputed to be 8,000 or 9,000 feet high. These present steep sides and jagged crests, and are believed to have escaped the glaciation that ground so heavily over the rest of the region. The largest of the numerous lakes in the interior plateau —Mistassini—is a hundred miles long. Many lakes have two outlets. The rivers on the plateau do not flow in deep or well defined valleys, but are prone to spread over the country in straggling channels; branches turn off unexpectedly on either side and, after an independent course of from five to fifty miles, rejoin the main channel. Every river is broken throughout its whole course by falls and rapids at irregular but generally short intervals, thus necessitating many portages in canoe traveling. Canyons like that of Hamilton river, and fjords like that of the Saguenay, are explained by Bell as the sites of deep-weathered dykes, cleaned out by glacial action. Grand falls on the Hamilton occur where this river plunges down the side of the canyon, which continues for twenty-five miles to the northwest, although not occupied there by any considerable stream. Recently elevated beaches occur along the eastern coast, up to 500 feet above the sea. Excepting in the north, the plateau is generally forest covered, but the trees seldom reach two feet, and are generally less than one foot in diameter. Great loss is caused by forest fires. The population is very scanty; 18,000 total, or about one to thirty square miles; and most of these live near the St. Lawrence and Atlantic coasts. About a thousand schooners, many of which carry several families, go from Newfoundland to the Atlantic coast to fish in the summer.

TRANSVERSE VALLEYS IN THE SOUTHERN ALPS.

FÜTTERER concludes a careful study of the 'Durchbruchsthäler in den Süd-Alpen'

*The constant term of Σ indicates that each star position of every catalogue must be corrected with $\Delta a = \grave{o}''.081 \tan\delta\cos(2L + a)$, $\Delta\delta = -0''.081\sin(2L + a)$. The last form of correction has been detected empirically by Gould in his own catalogue of Cordoba, and has allowed me to reduce greatly the systematic differences noticed by Downing between the catalogues of Greenwich, the Cape and Melbourne. (See *Annuaire* for 1894, p. 348 and 372.)

(Zeitschr. Gesell. f. Erdk., Berlin, xxx., 1895, 1–94), with the following reflections, here condensed: The most intimate knowledge of the geology of a river basin, including not only the composition of the strata but even reaching to the origin of their particles, is necessary to provide an interpretation of the origin and continual changes of a river system. Even in well-studied regions the results do not suffice to solve such problems, for unfortunately an interest in these 'geographical' questions is often absent among geologists. On the other hand, neither can the simple study of the actual condition of a river course explain the deeper problems of its geological development. As in the organic world, so here in the relations between mountain form and river courses, only from a knowledge of the processes of origin can we gain a true understanding of the world as it stands before our eyes (p. 92). This is sound physiographical doctrine. Fütterer discovers from the small remnants of ancient river deposits on the passes been the upper Tagliamento and the streams of the Carinthian Alps that these modern rivers are only feeble successors of a once much stronger river system that headed in the central Alps; and further that the Tagliamento, which exceeds both in drainage area and water volume the other rivers of the region, is only a *parvenu* among the Carinthian streams (91). The author notes (p. 78) a close agreement of his results with those obtained by Foerste in his thesis on the Drainage of the Bernese Jura (Proc. Boston Soc. Nat. Hist., 1892). Details are given concerning many streams, after which a general history of their development is presented (p. 76).

A SWISS LANDSLIDE IN THE GLACIAL PERIOD.

The valley of the Linth is obstructed for about four miles above (south of) the village of Glarus by a mass of loose material which Heim identifies as the product of an immense landslide or mountain fall (Der diluviale Bergsturz von Glärnisch-Guppen, Viertelj'schr. Naturf. Gesell. Zurich, xl, 1895, 1–32). The scar left by the fall is traceable on the lofty slope about two miles to the west. Morainic material lies upon the slide, and hence it is regarded as of at least glacial antiquity. Glacial action, however, not only did not suffice to clean out the valley, it did not even smooth down the rolling surface of the slide, or scrape away the river deposits that were accumulated up-stream from the barrier. The Linth now trenches the slide about half a mile back from its front on the eastern side of the original valley, as if the impetus of the slide had raised its margin to an uphill slope. The greatest thickness of the slide is 200 meters. Its original volume is estimated at $\frac{4}{5}$ km.^{3}, or about eighty times that of the great landslide of Elm in 1881. The Linth has now carried away about $\frac{1}{5}$ km.^{3}; 4,000 or 5,000 years being thought time enough for this work.

VALLEYS IN THE PLATEAU OF THE ARDENNES.

Arctowski describes this interesting region (Bull. Soc. géol. France, xxiii., 1895, 3–9) as the result of marine denudation of a vigorous ancient mountain system, the Cretaceous sea being regarded as the most active agent in accomplishing its reduction to baselevel. Following a miocene elevation of the region, streams began to sink their valleys beneath its even and gently sloping surface. The Hoyou, a branch of the Meuse from the north, and one of the most characteristic of the smaller streams of the Ardennes, exhibits several alternations between gentler and steeper slopes, although the points of increasing slope do not manifest any definite relation to the entrance of side branches or to the geological structure of the bed. Arctowski therefore concludes that the changes of slope indicate

upward movements of the region; the effect of the earliest movement having now been propagated nearly to the head of the stream, while the latest elevation has caused a deepening of the valley only near its mouth. (The lateral terraces that might be expected if this explanation were true are not mentioned.) The extremely meandering course of many deep valleys in the plateau is ascribed to lateral erosion on convex curves of originally irregular courses, and not to perpetuation of meanders originally developed on upland surface and somewhat increased during the incision of the present valleys.

THE RIVERS OF SPAIN.

THIS large subject is treated in a descriptive manner, with especial reference to the value of rivers for irrigation and navigation, by R. Torres-Campos (Bol. Soc. geogr. Madrid, xxxvii., 1895, 7–32, 81–140). The excessive aridity of many river basins and the dependence of agriculture on irrigation are the themes of many pages. In the basin of the Ebro, for example, irrigating canals create productive farms, sustaining a dense population; but away from the streams there is neither tree nor bush, and one may there travel 'leagues and leagues' without seeing the trace of human habitation. The dryness of this region has obliged many of the laboring classes to emigrate. Some go to South America, some to France; and the improved condition of the few who return stimulates the departure of others. On parts of the coast of Valencia the streams from the mountains have built out a sloping plain of fertile alluvium, where the construction of roads and canals has been so easy that the region is occupied by a prosperous and progressive population. No consideration is given by the author to the origin of the rivers or to the present stage of their development.

W. M. DAVIS.
HARVARD UNIVERSITY.

SCIENTIFIC NOTES AND NEWS.

FIELD WORK OF U. S. GEOLOGICAL SURVEY.

DIRECTOR WALCOTT, of the U. S. Geological Survey, has returned to Washington, after a two months' absence in the northern Rocky Mountain region, spent in field work. He was studying the Cambrian rocks and faunas of Montana and Idaho.

The field work of the season is drawing to a close. Nearly all the geologic parties have come in, though work is still going on on the Pacific coast, and, to a small extent, in the Interior or Mississippi basin. Work in the northern Rocky Mountain region and in Washington was brought to a stop early in October by severe storms. In this region Mr. Emmons and Mr. Willis were at work as well as the director. The special work in Alaska, an examination of the gold and coal resources, was advanced so far as conditions would permit, and Drs. Becker and Dall are now in Washington preparing their joint report on the subject. Since submitting to the Secretary of the Interior his report on the character of the lands involved in the McBride claim in Washington, Mr. W. Lindgren, who made the expert examination for the Government in that case, has been mapping the geology of the mining region of northern-central California.

Topographic work is still in progress in all quarters. The number of sheets surveyed is unusually large and the work is generally of excellent character. Surveys are, or have been, in progress in about twenty-five States and Territories. The Chief Topographer, Mr. Henry Gannett, made an inspection of the work, especially that in the West. The work going on in Indian Territory is of special interest because of the peculiar conditions governing it. Here, in connection with the regular topographic mapping, a subdivisional or parceling survey is being made in the interest of the General Land Office. This

work was much retarded in the summer months, partly by the illness of the men, due to the prevalence of malarial fever, and partly by other unforseen obstacles; but the conditions have improved and the work is now advancing with gratifying rapidity. This work will go on all winter.

Director Walcott will shortly prepare a succint report of the operations of the field season, for the information of the Secretary of the Interior, briefly reviewing the work in all its branches.

THE 'INSTITUT PASTEUR'.

The Paris correspondent of *The Lancet* gives in the issue of October 26 an interesting description of the Institut Pasteur, from which we quote the following facts:

The Institute is the property of a company, but having been recognized by the Government *d'utilité publique* it is under the control of the State (Home Office). The *Assemblée* is made up of founders; by it the Council is elected, the accounts passed, etc. The revenue is derived from the following sources: (*a*) the interest of 1,200,000 fr., balance of the sum of nearly 3,000,000 fr., publicly subscribed, about two-thirds of which was absorbed by the acquisition of the land upon which the Institute stands and by the building of the said Institute; (*b*) a subvention of between 20,000 fr. and 30,000 fr. made by the Agricultural Department for services rendered ('vaccinations' of animals against charbon, glanders, etc.); (*c*) a subvention (sum not mentioned) of the Ministry of Public Instruction to provide for the salaries of such officials as belong formerly to the École des Haute Études; (*d*) profits derived from the sale of vaccines supplied at a low rate to veterinary surgeons, these profits having been ceded to the Institute by M. Pasteur and by MM. Roux and Chamberland (the revenue from this source reaches about 20,000 fr. per annum); and (*e*) fees paid by the bacteriological students of the Institute.

The anti-diphtheric department, directed by Dr. Roux under the dual control of the Council of the Institute and the Ministry of the Interior, is an *annexe* of the Institute but has a distinct budget. The headquarters of this department are at Garches (where Pasteur died), on a property ceded to Pasteur by the State. The serum is distributed gratis, according to the demands of the Ministry of the Interior, to the army and to the hospitals and *bureaux de bienfaisance* of France and her colonies. The expenses are met by the interest of the public subscription (collected by the *Figaro*) and by a sum voted annually by Parliament (this year it amounted to 80,000 fr.). The serum is supplied to the public under the provisions of the Pharmacy Law, a small bottle being procurable at every druggist's for 3 fr. Any profit accruing from the sale will be devoted to the improvement of the particular *service*. The work done at the Institute comprises inoculations and lectures delivered by Drs. Roux and Metchnikoff, whose pupils are divided into two categories—those who are simply listeners and those who come to acquire the technique of bacteriology. There are, moreover, laboratories provided for investigators engaged in original research, the results of whose work are chronicled in the 'Annales de l'Institut Pasteur.' The teaching *personnel* is as follows: Biological chemistry, M. Duclaux, who is besides professor at the Faculty of Sciences, but who now gives his lectures at the Institute instead of at the Sorbonne, as was the case formerly. Rabies: Professor Grancher, with the collaboration of Drs. Charrin and Chantemesse. Sanitary bacteriology, 'vaccinations' and practical applications: M. Chamberland. Morphological bacteriology: Dr. Metchnikoff. Technical bacteriology: Dr. Roux. Finally, Professor Nocard, of the Alfort Ve-

terinary College, superintends a veterinary *service* attached to the Institute. The Institute, opened in 1888, will continue its activity under the same constitution as under its late chief.

THE PHENOMENA OF FRICTION.

M. RAFFARD has extracted from the technological publications of the *Société des Anciens Elèvès des Écoles nationale d'Arts et Métiers*, August, 1895, a paper* in which he summarizes the earlier work of Amontons (1699), of Coulomb (1781) and of Morin, Krest and Haton de la Goupilliére in our own times, and proceeds to the discussion of his own recent experiments, particularly on the friction of cords and belts on pulleys and cylinders about which they may be wrapped. As early as 1880 he had noted the fact that the friction of such flexible wrapping connections was very slight at low velocities rapidly increasing with acceleration of speed, and had presented the results of his work to the Society (Trans. 1880, p. 671). The experiments of Holman (Jour. Franklin Institute, Sept. 1885) confirm his own conclusions. Giving Holman's graphical illustration of the relation of friction of slipping belts to speeds, he makes the following final deductions:

1. In sliding friction the relative motion of the bodies is in line of the resultant of the applied forces.

2. With rolling friction the resistance remains substantially the same as when starting from rest, both in the plane of rotation and transversely to that plane, and a wheel will roll in its own plane, until the adherence is broken either by lateral or by circumferential stress, when it will at once take up a line of motion corresponding to the resultant of the acting forces.

3. The coefficient of friction of belts on turned and polished pulleys is at starting and at low velocities but about one sixth its magnitude at high speeds of relative motion.

* Considérations sur les Phénomènes du Frottement, N. J. Raffard, Paris, 1895. Pamphlet monograph. Pp. 15, 4.

GENERAL.

A BIOGRAPHY of Huxley is being prepared by his son, Mr. Leonard Huxley. *Nature* states that Mr. Huxley will be greatly obliged if those who possess letters or other documents of interest will forward them to him at Charter House, Godalming. They will be carefully returned after having been copied.

DR. HERBERT H. FIELD, whose address at present is 67 Rue de Buffon, Paris, announces that arrangements have just been made with Engelmann, of Leipzig, for a 'Bibliographia Zoölogica,' and with Fischer, of Jena, for a 'Bibliographia Anatomica.' The former will be sold in book form annually at $3.75, while in the card form it will be issued at the rate of $2.00 per thousand cards. Dr. Field announces that it is necessary to secure 75 subscriptions to the Bibliography, in book or card form, in the United States. This will be the most complete and systematic bibliography which has ever been issued, and deserves the prompt and generous support of zoölogists in all parts of this country. Subscriptions should be addressed directly to Dr. Field.

The Indian Engineer, a journal which has been published for quite a number of years in Calcutta, has recently changed its name to *The Indian and Eastern Engineer*, and extended its scope accordingly. Its object is to make engineers in the East acquainted with the best methods, American, English and Continental, employed in the industrial arts. Publications and articles descriptive of the arts and industries will be gladly received by the editor for republication in his journal. The editor of this journal is *C. W. Merton, 137 Cannings Street, Calcutta, India.*

Olzewski recently succeeded in producing a momentary liquefaction of hydrogen by allowing it to expand suddenly from 140 atmospheres' pressure, when cooled to about —210°C. with liquid air or oxygen boiling under a pressure of less than 20mm. Its boiling point under atmospheric pressure was found to be —243.5°C., only 30° above absolute zero. In a letter to Ramsay (*Nature*, Oct. 3) he now announces that under the same conditions *helium* shows no sign of liquefaction. Its boiling point is therefore still lower than that of hydrogen, and it is the most volatile substance known. In view of the great difficulty in reaching still lower temperatures, it would seem that the present methods will have to be considerably improved before helium can be liquefied.

Cassel & Co., London, and Macmillan & Co., New York, will publish shortly: 'Clerk Maxwell and Modern Physics' by R. T. Glazebrook. Other volumes of the Century Science Series are: 'Michael Faraday, his Life and Works,' by Sylvanus P. Thompson; 'Humphrey Davy,' by T. E. Thorpe; 'Pasteur, his Life and Work,' by M. Armand Ruffer; 'Charles Darwin and the Origin of Species,' by Edward B. Poulton; and 'Hermann von Helmholtz,' by A. W. Rücker.

Macmillan & Co. are about to issue a second edition of *Mental Development in the Child and the Race*, by Prof. J. Mark Baldwin. The only important alteration is the correction in the tables on page 51.

Inasmuch as New Jersey has now been covered by the topographical maps of the Survey, Mr. Henry Gannet has been enabled to prepare a dictionary of all the names on them and to give references to the particular sheets on which they occur. The dictionary facilitates very much the locating of obscure places, such as villages, brooks, hills, etc., and enables one to quickly acquire a map of any portion of the State. The dictionary is published as Bulletin 18 of the U. S. Geological Survey.

Mr. Edward Wheeler Parker has extracted from the sixteenth annual report of the Director of the United States Geological Survey his paper on the Production of Coal in 1894. After a brief introduction, descriptive of our American coal fields, a review of the production and labor statistics follows. A coal-trade review by business centers appears next, and then an account of recent official tests of various coals by the Navy Department. The bulk of the paper is occupied by the review of the several coal-producing States in alphabetical order. A geographical outline of the productive fields comes first, followed by statistics alike of output, labor, expenses, accidents and similar facts. Although concise, the paper is thorough and maintains the high character that has been established by the volumes on Mineral Resources.

The *Critic* states that an interesting collection of weapons, ornaments, etc., gathered in Africa by the young explorer E. J. Glave, is exhibited at the office of The Century Co., in whose service Mr. Glave met his death in the Dark Continent, last May.

It is stated that of 597 trees struck by lightning in the forest near Moscow 302 were white poplars; and farmers are advised to plant these trees as protectors against lightning.

D. James E. Garretson, dean of the Philadelphia Dental College, and known for his scientific contributions on diseases of the mouth, died on October 27th, at the age of 67 years.

Mr. Robert Brown, a distinguished botanist and traveller, died in London on October 27th, at the age of 53. Dr. Brown travelled extensively in North America and North Africa, and made important scientific contributions to botany, geology and zoölogy.

PROF. WILLIAM ABBOT PIKE died from pneumonia at Minneapolis on October 13th. He was for some years professor of engineering in the Maine State College and later held the same position in the University of Minnesota.

BARON LARRAY, member of the French Institute and of the Academy of Medicine, and known for his contributions to military surgery, died on October 8th, at the age of 87.

THE Manchester Museum has obtained a grant of £400 from the taxes collected for free libraries, which amount to about £20,000.

THE German Hygienic Association has offered a prize of 12,000 Marks for a paper on the efficiency of electric heaters. The essays must be written in German and sent to Professor Konrad Hartmann, Charlottenburg, not later than July 1, 1896.

THE *Popular Science Monthly* opens its forty-eighth volume in November under the name *Appleton's Popular Science Monthly*, with typography and paper materially improved. The journal will hereafter be published in England by Kegan, Paul, Trench, Trübner & Co. The ten articles of the current number are all concerned with anthropology, using this word in a wide sense. Professor Brinton's president's address before the A. A. A. S. is given, and among the other papers of interest is an illustrated article by Mr. H. P. F. Marriott, entitled 'Primigenial Skeletons, the Flood and the Glacial Period.'

SEVERE earthquake shocks were felt in the central States just after 5 o'clock on the morning of October 31st, affecting especially Ohio, Illinois and Indiana. On the following day, at 5:40 in the morning, violent shocks were felt at Rome. The convent of Santa Maria Maggiore was greatly damaged. A portion of the outer wall was overthrown and part of the ceiling has fallen. Four palaces and the Bank of Italy were so shaken that they are rendered unsafe for occupancy.

A MUNICIPAL museum was opened at Alexandria on September 26th containing a collection of antiquities belonging to the Greek, Roman and early Coptic periods. The municipality and the Alexandria Archæological Society are making excavations in the city and neighborhood, but hitherto their researches have proved only negative.

THE daily papers state that the Board of Managers of St. Luke's Hospital, New York, at a recent meeting decided to erect on the new site of the hospital, at One Hundred and Eighteenth street and Morningside avenue, a large building to be devoted exclusively to researches in pathology. It is to be specially devoted to investigation of dangerous micro-organisms. The managers appointed a committee with full power to erect the building, and declared it their opinion that an endowment fund of $200,000 should be obtained and set aside for the pathological department. The plans of the new building have already been drawn up and will be submitted to the Medical Board in a few days. The building as designed will be one of the finest and most complete in appointments of any similar structure in America.

D. APPLETON & Co. announce two new volumes in the International Scientific Series, *Greenland Icefields*, by Prof. G. Frederick Wright, and *Movement*, by E. J. Marey.

THE French Association for the Advancement of Science will hold its next meeting in Tunis in April, 1896. In 1897 it will meet in St. Etienne. M. Distère, marine engineer, has been elected president of the Association and Dr. Leon Teisserenc de Bort general secretary.

DR. W J MCGEE, of the Bureau of American Ethnology, has started to explore

the hitherto unknown portion of Sonora county, Mexico, and Tiburon Island, on the coast of Mexico, inhabited by the Seri Indians, noted for their treacherous bloodthirstiness.

ACCORDING to *Nature* the Catalogue of the Library of the Royal Geographical Society, compiled by Dr. H. R. Mill, and lately published, is a very full and valuable index to the literature of geography. The Catalogue contains the titles of all works in the possession of the Royal Geographical Society published up to the close of 1893. The entries (amounting to as many as 18,000) are arranged in four divisions. The first division, which runs into 521 of the 833 pages, is a general alphabetical author's catalogue; the second comprises collections of voyages and travels, arranged in alphabetical order under authors' names, and containing a brief analysis of the contents of each volume; in the third division, government, anonymous and other miscellaneous publications are arranged geographically; while the fourth consists of a list of transactions and periodical publications, arranged in a similar manner according to the place of publication. With such a comprehensive classification, it is easy to find the works of each author and to refer to the literature concerning different divisions of the earth. A valuable supplement to the Catalogue will be the subject index now being prepared and in which the principal contents of all the geographical books and periodicals belonging to the Society will be classified.

A MONUMENT to Duchenne by M. M. Desvergnes and Debrie will shortly be erected in the Salpêtrière. It is also proposed to erect a memorial to Duchenne in his native city of Boulogne.

IT is said that Professor Wollny, of Munich, has made some experiments which prove the utility of angle-worms for agricultural purposes. He raised peas, beans, potatoes and other vegetables in wooden boxes, some with and some without worms, and in each case the presence of worms led to an increase in the crop, varying from twenty-five per cent. in the peas to ninety-four per cent. in the rye.

THE Canadian Medical Association will hold its annual meeting for 1896 in Montreal under the presidency of Dr. James Thorburn.

THE total number of new students who have entered the twelve London medical schools is 581, as compared with 552 in 1894.

MR. C. H. COCHRANE states in Lippincott's Magazine that the National Rapid Transit Company is asking the United States Senate for privileges looking to the establishment of a line between New York and Washington, and specifying in the proposed bill that the schedule time shall not be less than one hundred miles an hour, which necessitates a speed of a hundred and twenty miles per hour to cover loss from stops. Further, the General Electric Company of New York is willing to guarantee motors, generators and other electric mechanism for such a road, warranting them to maintain a speed of one hundred and fifty miles an hour when delivering a hundred horse-power per motor with two motors per car.

The New York Evening Post states that the documents of the Arctic explorer Jackson, brought back from Franz Joseph Land by the Windward, have been opened in London. They record that the expedition landed on September 7, 1894, at Cape Flora, where log houses were erected and a tempestuous winter was spent. Jackson and two others started north March 10, 1895, with two ponies and two sledges. The temperature was sometimes 45 degrees below zero. The country generally was 2,500 feet above sea level and was covered with

ice sheets, interrupted along the cost by high basaltic cliffs. The journey revealed many inaccuracies in the charts. The farthest point reached was latitude 81 degrees 20 minutes north, where two boats were left for use later in the summer. Many specimens were taken, which show that the geological formation of the land is mainly basaltic. A second journey began in April and ended in the middle of May. It was attended with stormy weather, and frequently the temperature was 50 degrees below zero. Jackson considers horses the best means of reaching a high latitude up to the end of April.

THE *Times* states that a series of archæological discoveries have been made at Monkswood, near Bath, where a reservoir is being constructed to supplement the water supply of the city. The latest discovery was unearthed on Thursday from a mass of peaty deposit. It is an iron hatchet with a handle formed of a human leg bone. Round the socket is a rough ferrule of lead. The metal head was kept firm by means of wooden plugs, traces of which were found clinging to the iron. This is the only relic of the iron age discovered, but oölitic flint hammer heads and an interesting collection of bronze weapons and articles of personal adornment have been brought to light. These discoveries have been inspected by Professor Boyd Dawkins and other paleontologists. The bones of extinct mammalia have also been met with. The discoveries are in the charge of Charles Gilby, city engineer of Bath.

UNIVERSITY AND EDUCATIONAL NEWS.

THE corner stone of the new dormitory buildings of the University of Pennsylvania was laid on November 5th, Judge Robert M. Willson, Provost Charles C. Harrison and Bishop O. W. Whitaker taking part in the ceremonies. The dormitories are due to the initiative of Vice-Provost George Stuart Fullerton and are planned on an elaborate scale, it being estimated that $1,000,000 will be required to complete the buildings. They will include a dining hall and a chapel in addition to forty-four houses, forming one continuous building. Each house will have a separate staircase and will accommodate twelve to fourteen students with bedrooms, sittingrooms and bathrooms. There will be two courts, one triangular and one rectangular, separated by cloisters. The sixteen houses forming the triangle are already in course of erection and will be ready for occupation at the opening of the next academic year.

THE Public Hall of the University of Virginia, and the Rotunda, which contained the library, were completely destroyed by fire on October 27th. The loss is estimated at from $150,000 to $250,000, with an insurance of $25,000. Efforts are already being made to collect money to restore the buildings, as they were before their destruction, and had been planned by Jefferson. A large part of the books in the library were saved, but many valuable papers and rare books that can never be replaced were destroyed.

THE trustees of Cornell University have voted $2800 to build a small working observatory for the College of Civil Engineering.

THE *Bulletin of the American Mathematical Society* announces the following appointments: Prof. Samuel L. Barton, recently of the Virginia Agricultural and Mechanical College, to be professor of mathematics in the University of the South, Sewanee, Tenn.; Dr. Alex. Macfarland, formerly professor of physics at the University of Texas, to be lecturer in Lehigh University; Dr. E. B. Van Vleck, formerly of the University of Wisconsin, to be associate professor of mathematics in Wesleyan University, and Prof. C. A. Waldo, of De Pauw Univer-

sity, to be professor of mathematics at Purdue University.

The free lecture courses on literary, scientific and technical subjects established by the trustees of the Lowell Institute, under the supervision of the Massachusetts Institute of Technology, Boston, began on November 4th. Twenty courses are offered, each consisting of twelve lectures.

At the annual meeting of the Chicago Alumni of Mt. Holyoke College, on October 24th, Dr. D. K. Pearson offered to give $150,000 to the College, provided the alumni would raise an additional $50,000.

The Rev. H. E. Cushman has been appointed assistant professor in philosophy in Tufts College.

Rev. Dr. R. J. Pearce has resigned from the chair of mathematics at Durham University to take effect next Christmas.

Prof. König, of Göttingen, has been offered the chair of surgery at Berlin, vacated through the death of Professor Bardeleben.

The *Naturwissenschaftliche Rundschau* states that Dr. Ernst Lecher has been appointed to a chair of physics in the University of Prague; Dr. W. Müller has been offered a professorship and the position of director of the Zoölogical Institute of the University of Greifswald; Dr. Beck, a geologist of Leipzig, has been appointed professor of geology in the *Bergacademie* of Freiberg i. S.; Dr. Günther Beck von Mannagetto, professor of botany at Vienna; Dr. Rothpletz has been promoted to an assistant professorship at Munich; and J. C. L. Wortman to a professorship in the experiment station for chemical agriculture in Geisenheim. Dr. Karl Claus, professor of zoölogy in Vienna, has been retired.

CORRESPONDENCE

EXPERIMENTAL PSYCHOLOGY IN AMERICA.

To the Editor of Science: *The American Journal of Psychology* began a new series last week with an 'editorial' introduction, in which some most extraordinary statements appear. As an official of Harvard University I cannot let one of these pass without public contradiction. The editorial says (on the top of page 4) that the "department of experimental psychology and laboratory" at Harvard was "founded under the influence" of some unspecified person mentioned in a list of President Hall's pupils. I, myself, 'founded' the instruction in experimental psychology at Harvard in 1874–5, or 1876, I forget which. For a long series of years the laboratory was in two rooms of the Scientific School building, which at last became choked with apparatus, so that a change was necessary. I then, in 1890, resolved on an altogether new departure, raised several thousand dollars, fitted up Dane Hall, and introduced laboratory exercises as a regular part of the undergraduate psychology-course. Dr. Herbert Nichols, then at Clark, was appointed, in 1891, assistant in this part of the work; and when Professor Münsterberg was made director of the laboratory, in 1892, and I went for a year to Europe, Dr. Nichols gave my undergraduate course. I owe him my heartiest thanks for his services and 'influence' in the graduate as well as in the undergraduate department at Harvard, but I imagine him to have been as much surprised as myself at the statement in the editorial from which I quote—a statement the more remarkable in that the chief editor of the American Journal studied experimental psychology himself at Harvard from 1877 to 1879.

William James.

Psychological Laboratory,
Harvard University, October 19, 1895.

Editor of Science—*Sir:* In his truly remarkable Preface to the projected new series, the editor of the *American Journal of Psychology* puts forth the claim that the Yale psychological laboratory, like the other more prominent Eastern laboratories, was founded 'under the influence' of his pupils and of Clark University. Inasmuch as Yale University has an institutional interest in the truthfulness of this surprising claim, and inasmuch as I have reason to suppose that my influence and not President

Hall's led to the founding of its laboratory, I wish publicly to contradict him. This cannot be more effectively done than by calling attention to the facts of history.

Sixteen years ago, while at Bowdoin College and before I even knew of the existence of President Hall, I began the detailed study of the relations between the nervous system and mental phenomena. On coming to Yale, two years later, I continued diligently the same line of study, in the laboratory and with the kind assistance of Dr. James K. Thatcher, then professor of physiology in the Yale Medical School. To this line I soon added much research in the field of experimental psychology.

For several years I worked to the extent of twenty-five or thirty hours a week on a course of lectures on these subjects, which were illustrated by a small collection of material purchased by money granted for that purpose. Finally, in 1887, my 'Elements of Physiological Psychology' appeared, and in 1891 an abriged and revised treatise under the title of 'Outlines of Physiological Psychology.' Those were indeed days of small things; but the work done was honest and thorough, and it was pioneer work. As to the 'influence' of my books on the entire development of modern psychological study, in the laboratory and outside of it, in this country and in England (where several editions of them have been sold and where they have been required in examinations for a degree in medicine) and further abroad, I leave the impartial historian to discourse.

Three years ago, since my own work—especially with graduate students—had outstripped my powers, an instructor in experimental psychology and a man who could supervise the putting in order of a laboratory was sought. Dr. E. W. Scripture, on my nomination, was given an appointment for that purpose. But so far even as the fitting-up of the laboratory came under his influence, it is not true that this emanates to any appreciable extent from President Hall or from his University. For Dr. Scripture, a graduate of the College of the City of New York, spent the three long semesters from 1888 onward in Leipzig, in Wundt's laboratory, and the two intervening summer semesters at Berlin and Zurich with Zeller, Paulsen, Diels, Ebbinghaus, Avenarius and Forel. At the time of his appointment at Yale he had indeed been, for about a year and a half, at Clark as a fellow, reading somewhat miscellaneously and using the laboratory as he chose, but without any regular instruction or supervision. His training, his instruction, his methods, are wholly from the Leipzig laboratory, and not at all from Clark University. This is, in fact, the entire extent of the 'influence' exerted by the writer of this truly remarkable Preface over the founding and development of the Yale psychological laboratory.

I will only add that two of the names mentioned in President Hall's list are much more pupils of Yale than of Clark. They belong among the twenty-three or twenty-four professors of psychology and philosophy which Yale has sent forth during the last fourteen years. Their *alma mater* is proud of them all; but not less so, because she has imparted to them a distinctly different spirit and *morâle* from that displayed in late years by the writer of this Preface.

GEORGE TRUMBULL LADD.

YALE UNIVERSITY.

EDITOR OF SCIENCE: According to an editorial statement in the *American Journal of Psychology* for September, the Laboratory for Psychology in the University of Toronto was founded 'under the influence' of pupils of Stanley Hall. This is false. The Toronto Laboratory was founded by myself, then professor there, with an appropriation gained by my exertions and influence with the educational authorities of Ontario. No pupil of Dr. Hall had any influence in the matter in any shape or form, for my early training was gained at Princeton, where Dr. Hall's influence was not large!

Moreover, the general claim made by Dr. Hall in the 'editorial' to the paternity of scientific psychology in this country is ambitious to an extraordinary degree. In Princeton alone a course in physiological psychology was given by McCosh, with practical work by Professors Scott and Osborn, as far back as 1883.

J. MARK BALDWIN.

PRINCETON UNIVERSITY.

It seems a pity that President Hall, who has accomplished so much for the advancement of

psychology in America, should claim in an editorial article in the last number of *The American Journal of Psychology* that he has accomplished nearly everything. The scientific and academic growth of psychology in America during the past fifteen years has been notable, but the cause must be sought chiefly in the progress of science as a whole and the sharper differentiation of psychology from the other sciences. Even those who have done the most are representatives of such a movement, not causes of it. In the article in question it is stated that "under the influence of these men [those who received their training under President Hall] departments of experimental psychology and laboratories were founded at Harvard, Yale, Philadelphia, Columbia, Toronto, Wisconsin and many other higher institutions of learning." Professor James introduced experimental psychology at Harvard University, Professor Ladd at Yale University and Professor Baldwin at the University of Toronto, and their names do not appear on President Hall's list of former students. I began the work at the University of Pennsylvania with the coöperation of Professor Fullerton (where it is continued by one of our former students, Professor Witmer), and at Columbia College with the coöporation of Professor Butler. I am glad to have had the privilege of studying for four months under Dr. Hall at Johns Hopkins University, but I had previously studied for two years under Lotze and Wundt and held an appointment at Johns Hopkins University for some months before Dr. Hall was called as lecturer to that University. The other men mentioned first on President Hall's list—Professors Dewey, Jastrow (who began the work at the only remaining university mentioned) and Donaldson—were also members of Johns Hopkins University before Dr. Hall.

In the same editorial article it is stated that *The American Journal of Psychology* wishes to publish especially 'the results of experimental investigations in psycho-physic laboratories,' an '*Archiv* function not yet represented by any serial publication in this field in English.' It is, however, easy to verify the fact that during the past two years *The Psychological Review* has published some forty-two experimental investigations in psychology whereas *The American Journal* has published but twenty-seven.

J. McKeen Cattell.
Columbia College.

THE RADIOLARIAN EARTHS OF CUBA.

To the Editor of Science: The occurrence of Radiolarian earths in the land structure of the West Indian region has been of special interest to geologists, owing to the fact that they probably represent profound organic sediments of the deeper floor of the sea. The discovery of these earths in Barbados and Trinidad had excited wide interest, but little light had been obtained upon the important question of their geologic age.

In my recent papers* on the geology of the Island of Cuba, I have briefly described the geology of some interesting beds of siliceous earths which I collected from a locality in the suburbs of the town of Baracoa, and personally determined with the microscope to be composed of radiolarian remains. Through the determinations by Dr. Dall of fossils collected by me from the overlying strata, I was enabled to point out the important fact that they occurred immediately below strata containing fossils of undoubted Miocene age, and published a figure illustrating their geologic relations.

I was not aware at the time of making this publication that the existence of radiolarian beds in Cuba, much less at this particular locality, was known, as they are not mentioned in Professor Crosby's paper,† the only one previous to mine based on personal studies of the region.

In an article on the geology of the Barbados (to which Mr. J. W. Spencer has called my attention) by Mr. A. J. Jukes-Browne, published in the Quarterly Journal of the Geological Society of London for May 2, 1892, p. 221, the following interesting paragraph occurs:

"Cuba.—When this paper was read, Mr. J. W. Gregory was able to announce, from the examination of rocks he had obtained from Baracoa in Cuba, that radiolarian earths existed in that island; he finds them to be similar in structure

* American Journal of Science, September, 1894. Notes on the Geology of the Island of Cuba. Based upon a reconnoissance made for Alexander Agassiz, Cambridge, Mass.

† On the Elevated Coral Reefs of Cuba. Proc. Boston Society of Natural History, Vol. XXII., pp. 124–129.

and mode of occurrence, and also in their calcareo-siliceous varieties, to those of Barbados."

This previous publication clearly entitles Mr. Gregory to the original announcement of the radiolarian earths in Cuba, and had I known of its existence he should have received credit therefor in my papers, and my work has only resulted in the approximate determination of their age and mode of occurrence. The nature of Mr. Gregory's discovery is more fully explained, however, in a recent paper* in which he clearly sets forth the fact that he found these rocks, not in Cuba, but in Boston, in the collection made by Prof. W. C. Crosby in the Museum of Natural History, and refers to my preliminary paper for the facts concerning their occurrence and age. In this paper he also presents an interesting paleontologic study of this material showing the presence of 17 families, 25 genera and 33 species.

These are the facts concerning the knowledge of the radiolarian beds of Cuba: The material was first collected by Professor Crosby; their radiolarian nature determined from Professor Crosby's collections in Boston by Mr. Gregory; their geological occurrence and age described by the writer from studies on the ground, and their specific paleontology determined by Mr. Gregory.

On page 311 of Vol. 51 of the Quarterly Journal of the Geological Society of London, dated August, 1895, as a portion of the discussion following the delivery of Mr. J. W. Gregory's article on the Paleontology and Physical Geology of the West Indies, Mr. A. J. Jukes-Browne is quoted as follows:

"In view of these facts, we are quite prepared to accept Mr. Gregory's conclusion that the Oceanic Series is of Miocene age, the more so as Mr. Spencer has come to the same conclusion with respect to the Radiolarian Earths of Cuba, after a personal study of the geology of that island."

Inasmuch as Mr. Spencer makes no claim of having ever visited eastern Cuba, and has only seen the material from Baracoa which the writer collected, the above paragraph is liable to convey an erroneous impression concerning the discovery of the age and existence of these important beds.

ROBT. T. HILL.

WASHINGTON, D. C., October 16, 1895.

* Paleontology and Physical Geology of the West Indies. Quarterly Journal of the Geological Society of London, August, 1893, pp. 293–95.

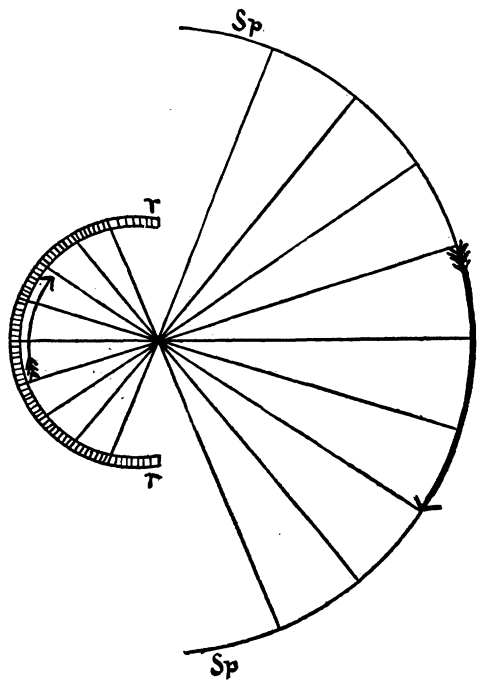
ERECT VISION AND SINGLE VISION.

PROF. CATTELL'S criticism of Prof. Brooks (SCIENCE for October 11, p. 487) in the matter of the inverted retinal image is undoubtedly just, but his reply has not made things any clearer. There is nothing specially inconceivable nor specially inexplicable about erect vision with inverted retinal image. It can be explained, too, without 'standing the soul on its head.' This may be a metaphysical but surely not a scientific explanation. In science what we mean by an explanation is a reducing of the phenomena in question to a law, which includes many other phenomena and especially the most common and familiar phenomena. Now, the seeing things in their natural or real position by means of inverted retinal images is a necessary result of the *law of direction*, and this law is the most familiar fact of common sensation. Let me explain:

Suppose I was standing on the plains of Arizona, captive, bound and blindfolded, surrounded by Apaches and a target for their arrows. I think I could tell with reasonable certainty the general direction of the Apache who shot any particular arrow. I would know it by the part struck and especially by the direction of the push of the arrow. I would refer the cause back along the line of the push to the proper place. There is nothing especially inconceivable in this. Now, suppose I look at the horizon. A star (I take this because it is a point) sends its ray into my eye through the optic center or nodal point, and it strikes a certain rod or cone on the lower half of the retinal concave. Is it anything specially strange that the impression—the punch—should be referred back along the line of the punch (ray line) to its proper place in space and, therefore, that I should see the star *above* the horizon? Now, objects are made up entirely of such stars—*i. e.*, radiant points—each sending its ray straight to the retinal concave, all crossing one another at the nodal point and therefore making an inverted image. But *each focal impression* (focal point) *of the image is referred back along its own*

ray line to its own place; and thus the external image is *reinverted in the act of external reference,* and reconstructed in space in its true position as the sign and facsimile of the object that made it.

These facts will perhaps be made still clearer by the following diagram in which *r*, *r*, and *sp*, *sp*, represent the retinal and spatial concaves.



Every point, every rod and cone of the retina, *has its fixed correspondents in space,* and these correspondents *exchange* with one another by impression and external reference. The arrow and its retinal image are introduced to render the subject, if possible, still clearer. Although, indeed, I thought I had already made it sufficiently clear in my little book 'Sight,' pp. 83–89.

It is seen, then, that there are two fundamental laws underlying monocular vision: First, the law of external projection of retinal impressions into space. Second, the law of direction, *i. e.*, the mathematically definite direction of this projection. These two laws explain every phenomenon of monocular vision except *color perception.*

So again the apparent anomaly in Binocular vision of single vision with two retinal images is, it seems to me, easily explained so far as sense perception is explicable by science at all. Those who observe closely their visual phenomena know perfectly that except under well known conditions we *do* see *two objects* or *rather two external images* of every object, and we know perfectly well which corresponds to, or is produced by, each retinal image. We *see objects single only when these two external images of the same objects are placed one on the other and made to coincide.* This takes place when the two retinal images of the same object fall on what are called corresponding points of the two retinæ; because then, *by the law of direction* already explained, *they are thrown to the same place in space* and their external corresponding images coincide. Anyone accustomed to binocular experiments can at will separate these images and then bring them closer and closer, observing them the while, until they coalesce and the object is seen single. Is not this a sufficient explanation?

Joseph Le Conte.
Berkeley, Cal., October 17, 1895.

SCIENTIFIC LITERATURE.

A Text-book of Mechanics and Hydrostatics. By Herbert Hancock, M. A., F. R. A. S., F. R. Met. Soc. New York, D. Van Nostrand Co. 1894. Pp. viii+409.

It goes without saying that the task of preparing a good elementary book on mechanics is now far easier than at any previous epoch in the history of the science. The clarification in fundamental ideas and the fixation of terminology which have come about during the past thirty years would seem to make it difficult for an author to depart very widely from sound definitions and logical development. It is somewhat surprising, therefore, to find a book whose author acknowledges his indebtedness to Maxwell, Thomson and Tait, and Clifford, marred by the very confusion of ideas which those eminent teachers have done so much to banish from mechanics.

Our suspicion of the author's fitness for his work is raised in the first paragraph of his preface, wherein he gravely affirms that "past experience leads me to conclude that no complete knowledge of mechanics can be got without some knowledge (however elementary) of

such subjects as plane trigonometry, variation and mensuration, etc., and with this in view I have premised the book by a simple statement of the methods of measuring angles, and the geometrical meanings of sine, cosine, etc., of an angle with simple explanation of the other operations." This might suffice to indicate the nature of the book, but it seems only fair to the public to give a few more specimens of the author's ideas. Naturally, we look to his chapters entitled 'Inertia and the Laws of Motion' and 'Energy and Work.'

In the former chapter, p. 83, we read, "From a large number of experiments we conclude that matter is incapable of changing its own state. This inert or passive condition is called the inertia of matter, and the law which regulates it is called the law of inertia." On p. 86, in reference to Maxwell's statement that "the change in momentum of a body is numerically equal to the impulse which produces it, and is in the same direction," the author remarks that "this law is sometimes called the law of impulse. We must be careful to distinguish between an impulse and impulsive force." Notwithstanding this caution, he says a few lines further on, "An impulse is a force which in a finite time produces a definite change of momentum." In the chapter on work and energy, p. 223, we are told "that there are many forms of energy, such as heat, light, chemical action, electricity, magnetism, etc. On this account the term mechanical energy is sometimes used to denote kinetic and potential energy." On p. 224, in explanation of a foot-poundal he tells us "this is sometimes called the absolute or kinetic unit of force. This unit," he adds, "was given by Newton, and it is probably the most accurate."

These illustrations, which might be easily multiplied to a wearisome extent, may serve to show the utterly chaotic character of the work in its treatment of fundamental principles. The author demonstrates clearly that if he has read the works of Maxwell, Thomson and Tait, etc., at all, he has read them to no purpose.

Mechanics (Dynamics). An Elementary Text-book, Theoretical and Practical, for Colleges and Schools. By R. T. GLAZEBROOK, M. A., F. R. S. Cambridge, at the University Press, New York, Macmillan & Co. 1895. Pp. xii.+256.

This little book on dynamics is one of the 'Physical Series of the Cambridge Natural Science Manuals.' It is the outgrowth of the author's experience in giving a practical course of lectures and laboratory work in mechanics to students of medicine. The result is one of the best elementary books we have seen—one well worth reading, in fact, by those who have passed beyond the elements of the science. "Mechanics" the author says, in his preface, "is too often taught as a branch of pure mathematics. If the student can be led up to see in its fundamental principles a development of the consequences of measurements he has made himself, his interest in his work is at once aroused, he is taught to think about the physical meaning of the various steps he takes and not merely to employ certain rules and formulæ in order to solve a problem." This gives the key to the plan of the book, and so well is the plan executed that even the dullest reader cannot fail to get instruction if he comes to the subject without erroneous preconceptions.

The book is divided into eleven chapters, which are characterized throughout by clearness and precision of statement and aptness of illustration. The first chapter deals with units and methods of measurement and with the terms used in mechanics. Chapters II and III are devoted to kinematics, the first to velocity and the second to acceleration. Chapters IV and V treat of momentum and the time rate of change of momentum respectively. The term *force*, concerning which there is commonly enough obscurity even with mechanicians, and a sort of abysmal profundity with those philosophers who are not naturalists, appears in Chapter V as the name for the rate of change of momentum.

These first five chapters furnish what the author considers a sufficient inductive foundation for the science. Thenceforth he proceeds by deduction chiefly. Thus, at the close of the fifth chapter he says: "We are now about to make a fresh start and consider Dynamics as an abstract science based on certain laws or axioms which were first clearly enunciated by Newton and are called Newton's Laws of Motion. We

shall endeavor in the next chapter to explain these laws and to show how they may be illustrated by the simple cases of motion already discussed; we then go on to assume them as true always and to deduce their consequences in other cases." By way of proper caution he adds, however, that "We shall not now discuss the question whether these fundamental principles were stated in their best form by Newton. Our present object is to give a consistent account of the Science of Mechanics as it has been developed from Newton's laws."

The following chapters VI–VIII are devoted to the consideration of Newton's laws of motion and the consequences deducible therefrom. The presentation of these matters is admirable and must take rank with that given in the best works hitherto published. Indeed, though the book professes to be elementary only, its exposition of these matters appears to be as luminous and complete as can be given without the aid of the calculus.

The last three chapters deal with curvilinear motion of a particle under gravity, collision of masses, and motion of a particle in a circle respectively. The book has many well chosen illustrative examples, whose answers are given in most, though, properly, not in all cases. There are a few samples of examination questions given, and the book terminates with a good index.

The faults of the work, if any may be fairly urged against it, are faults of omission rather than of commission. The only one which seems worthy of mention is the absence of an explanation and a use of the theory of the dimensions of the units which figure in mechanical quantities. Nothing, we believe, helps more to fix ideas with regard to the terms force, momentum, energy, etc., in mechanics than a knowledge of that theory, while its application is of great aid to the student in detecting and in correcting his blunders. An application of this theory, for example, will immediately detect the misprint in the formula on p. 187 of the book; though it is but just to add that this is the only misprint which that theory has disclosed in our reading of the book. We may express the hope that future editions of this capital work will be improved by the addition of an appendix explaining the doctrine of units and dimensions of units in mechanical quantities and indicating the great utility of the doctrine to students and investigators.

R. S. Woodward.

Fourteenth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1892–93. By J. W. Powell, Director. Part I. Report of the Director. Part II. Geology—accompanying papers (Vignette). Washington, Government Printing Office. 1893. 8°, 2v.

Volume I., of 321 pages, is taken up by the administrative reports of heads of divisions and by other executive matters. The only general interest that it possesses lies in the fact that it sets forth the plans and policies of the Director and of the above officials. The second volume contains a valuable series of accompanying papers, viz:

1. Potable Waters of the Eastern United States, W J McGee, pp. 5–47.

2. Natural Mineral Waters of the United States, A. C. Peale, pp. 53–88.

3. Results of Stream Measurements, F. H. Newell, pp. 95–155.

4. The Laccolitic Mountain Groups of Colorado, Utah and Arizona, Whitman Cross, pp. 165–241.

5. The Gold-Silver Veins of Ophir, California, Waldemar Lindgren, pp. 249–284.

6. Geology of the Catoctin Belt, Arthur Keith, pp. 293–395.

7. Tertiary Revolution in the Topography of the Pacific Coast, J. S. Diller, pp. 403–434.

8. The Rocks of the Sierra Nevada, H. W. Turner, pp. 441–495.

9. Pre-Cambrian Igneous Rocks of the Unkar Terrane, Grand Canyon of the Colorado, Arizona, Charles D. Walcott, with notes on the Petrographic Character of the Lavas, by Joseph Paxson Iddings, pp. 503–525.

10. On the Structure of the Ridge between the Taconic and Green Mountain Ranges in Vermont, T. Nelson Dale, pp. 531–549.

11. On the Structure of Monument Mountain in Great Barrington, Mass., T. Nelson Dale, pp. 557–565.

12. The Potomac and Roaring Creek Coal

Fields in West Virginia, Joseph D. Weeks, pp. 573–590.

The first paper has popular interest but no geological importance. The second is an excellent summary of the country's mineral springs and will be often serviceable for reference. A list of the leading ones by States is included. The third paper has valuable data on the amount of flow in Western rivers, and on the Potomac, Connecticut and Savannah in the East. It will aid in the advancement of irrigation in the West, and our general hypsometric knowledge. The fourth paper is a most important contribution to the geology and petrography of the area discussed. It shows the great part played by laccolites in some of the best known Colorado mountains and the close parallelism that exists among them all in the character of the rocks. In the fifth paper Mr. Lindgren ably discusses the interesting gold-quartz veins of the Ophir district, Placer county, and draws some well based conclusions as to their method of origin. In the sixth paper Mr. Keith brings out a vast amount of new and important knowledge about the metamorphic and paleozoic belt that passes from Pennsylvania south through Hagerstown and Harper's Ferry, Md., and across West Virginia and Virginia to the Rappahannock River. Besides describing the local structural geology, and its development the paper includes an important contribution to the dynamic metamorphism of pre-Cambrian igneous rocks, both plutonic and volcanic. In the seventh paper Mr. Diller takes up the Tertiary changes in that most interesting problem, the recent geological history of the Pacific coast. The ancient base levels are traced and many important conclusions are deduced, which have a close connection with the auriferous gravels. Mr. Turner's paper (the eighth) presents an admirable review of the geology of the Sierras and adds greatly to our knowledge of their petrography. In the first part of the ninth paper Mr. Walcott describes the relations of the pre-Cambrian lava sheets to the other Algonkian terranes of the Grand Canyon, and gives detailed sections and views. Prof. Iddings identifies them as surface or submarine flows of basalt. In the tenth and eleventh papers Prof. Dale extends the area covered by his previously published work in the metamorphic belt of the New York and New England border and especially in the latter, clears up the geology of a mountain famous alike for its geology and lovely scenery. Both papers are also important contributions to our knowledge of the mineralogical changes involved in the passage of sediments into schists and marbles. In the last paper Mr. Weeks describes, under the name of the Potomac basin, the important coal field that extends from Wellersburg, Pa., across Maryland into West Virginia, and that embraces the Cumberland or George's Creek coal of Maryland, and the Elk Garden and Upper Potomac coals of West Virginia. Analyses, sections and statistics are given.

The Production of Tin in Various Parts of the World. By CHARLES M. ROLKER. Advance excerpt from the Sixteenth Annual Report of the Director of the U. S. Geological Survey. 1894–1895. Part III. Mineral Resources of the United States. Calendar Year. 1894. Pp. 1–88.

It would appear from the above reference that the forthcoming annual reports of the Director of the Survey are to have a regular department devoted to Mineral Resources. This is to be warmly commended, both because it affords material that is of value to the general public, which is after all the Survey's real constituency, and because it caters to the scientific public as well. Many friends of the Survey have viewed with regret in recent years the small prominence that this portion of its work has received, and have felt that it was a mistaken policy.

Mr. Rolker gives an admirable and concise review of tin ores, their geology, statistics and the expense of production the world over. The report covers much the same ground in many respects as that treated by Professor Ed. Reyer in his 'Zinn, eine geologisch-montanistisch-historische Monografie,' that appeared in Berlin in 1881, but Mr. Rolker brings the subject down to date, omits many theoretical discussions and makes especially prominent those points that are of importance in their practical relations. The geology of cassiterite is curiously uniform, wherever the mineral is found. Veins in or

near granite or gravels yielded by them are its sources, whether it be in Cornwall, the Zinnwald, the Malay peninsula or Australia. The large part played by tin in the bronze implements of the ancients and even in prehistoric commerce give it peculiar claims to interest. Enormous attention has been devoted to tin mines in this country of late years, so much that the metal has even been a political factor, loudly heralded in recent campaigns. All our enterprises have as yet been without success, and some are instructive examples of extravagant folly. Mr. Rolker's dispassionate and truthful descriptions are timely and much to be commended.

J. F. Kemp.

The Natural History of Plants, their Forms, Growth, Reproduction and Distribution, from the German of Anton Kerner von Marilaun. By F. W. Oliver, with the assistance of Marian Busk and Mary F. Ewart. With about 1,000 original woodcut illustrations and sixteen plates in colors. New York, Henry Holt & Co. 1895. 2 vols., large 8vo.

This is a most interesting and readable book. It is written in a clear and popular style; few technical terms are used, except where necessary for the sake of accuracy, and the illustrations are fine and full of interest. The whole plan of the work is to treat plants as living things and to find a biological significance for all the parts of which a plant is formed. Here will be found answered many of what may be called the practical questions about plants; such as why certain species grow in peculiar places, how they are adapted to the conditions which surround them, how they get their food, of what this food consists, how it is conducted and formed into organic matter, and the structures and forms resulting. As the author says, "For us no fact is without significance. Our curiosity extends to the shape, size and direction of the roots, to the configuration, venation and insertion of the leaves; to the structure and color of the flowers, and to the form of the fruit and seeds; and we assume that even each thorn, prickle or hair has a definite function to fulfil." The author claims the advantageous aid of imagination in his scientific researches and says that "the more imagination an investigator has the more keenly is he goaded to discovery by this craving for an explanation of things and for a solution of the mute riddle which is presented to us by the forms of plants." It is probably due to this feature of the work that it is so readable, and yet its scientific facts do not suffer on this account. The first four chapters are devoted to the living principle in plants. Protoplasts are considered as the seat of life; the discovery of the cell and of protoplasm is recounted with illustrations of both; the movements of protoplasts are illustrated from the swarm spores of seaweeds, and the mosses and ferns; the movements of Volvocinèæ, Diatomaceæ and Bacteria are described; the continuity of protoplasm through the cell walls and its relation to vital force and sensation are explained.

Under the heading of the Absorption of Nutriment, inorganic and organic foods are treated, the absorption of water and the character of soils, as well as the symbiotic relations of plants.

One of the most interesting chapters discusses the relations of the position of foliage leaves to that of absorbent roots, proving that the leaves conduct the rain to the point on the ground where the roots of the plant can get it; the peripheral increase of the leaves keeping pace with that of the roots. Most interesting diagrams are given of the position of leaves to facilitate this irrigation. In treating of Saprophytes illustrations are drawn of those in water, on the bark of trees and on rocks. Examples are cited from the simplest as well as the most highly organized plants, and many suggestions are given as to the habitats of plants.

The Absorption of Nutriment by parasitic plants is described at length and illustrated by numerous strange and unfamiliar examples. Carnivorous plants also receive ample attention and are illustrated by numerous cuts and a colored plate.

Under the heading of the Conduction of Foods, the author treats of the regulation of transpiration and the means by which leaves are protected from excessive dryness in exposed localities. The diversity in the structure of leaves is almost marvelous, and the figures given are of great variety and interest. In this

connection special adaptation to divers habitats brings about great differences in plants, and we find those of high altitudes and dry sunny locations differing widely from those of moist low places. Many of the problems of distribution and of special floras are touched upon in this connection. The special functions of the green leaves in the formation of organic food from the absorbed inorganic food; the transport of substances in living plants and the propelling forces in the conversion and distribution of materials constitute an interesting but a much more technical group of facts, leading naturally to the treatment of growth and ultimate structure of plants, till we reach the completed structures, passing by progressive stages in complexity from unicellular organisms to plant bodies and the forms of their roots, stems and leaves.

The remainder of the work is promised soon and will be looked for with much interest. The translators deserve a great deal of credit for the clearness of the style, the beauty of the text and the fine character of the illustrations, which are taken from the original plates, by permission of the author.

A traverse le Caucase. ÉMILE LEVIER. Neuchatel, Attinger Frères. 1894.

As the rest of the title indicates, these are the notes and impressions of a botanist, illustrated by numerous photographs taken by one of the party, Mr. Stephen Sommier, supplemented by others from the collection of Vittorio Sella, whose Alpine and Caucasian views are famous. The illustrations add great interest to the work, giving, as they do, views of the people, their towns and buildings, and the wild, picturesque country in which they live. The journal also is full of word pictures, and recounts in a lively and interesting manner the experiences of the party, the details of their journey as well as their adventures in the wild gorges among the snow-clad mountains which they traversed. Their experiences with the natives, the numerous courtesies and hospitalities received from the Russian officials, their adventures in search of plants and game, their photographic trials and anthropological researches, fill a large and handsome volume of 335 pages and hold the interest of the reader from beginning to end. A map completes the list of illustrations, one of which is a picture of the Botanic Garden at Tiflis. A list of new species detected is appended.

ELIZABETH G. BRITTON.

SOCIETIES AND ACADEMIES.

BIOLOGICAL SOCIETY OF WASHINGTON, 247TH MEETING, SATURDAY, OCTOBER 19TH.

MR. SYLVESTER D. JUDD read a paper entitled 'The Food of the Catbird, Brown Thrasher and House Wren,' in which he said that these three birds destroy beetles, ants, caterpillars, grasshoppers and many other insects; also, that the wren is exclusively insectivorous, but that the catbird and thrasher subsist largely on wild fruits, occasionally making inroads on cultivated varieties.

Mr. L. O. Howard spoke briefly of a new enemy of the Hellgrammite fly. In August of the present year Mr. R. S. Clifton called his attention to the fact that the egg masses of the Hellgrammite on the shores of the Potomac River were being eaten by some insect. Investigation showed that the egg masses, which had never before been known to be attacked by any insect, were being eaten wholesale by the larva of *Anthicus haldemanni*, an extremely rare Anthicid beetle. Of the hundreds of egg masses examined none were unattacked. The beetle gnaws a hole through the cover of the egg mass and lays its eggs within. The larvæ feed upon the Hellgrammite eggs until full grown, then crawl away to a crack in the rocks and transform to pupæ.

The speaker claimed especial interest for the observation from three facts: (1). The egg masses of the Hellgrammite were previously supposed so be uninfested by any insect enemy. (2.) *Anthicus haldemanni* is a very rare beetle, which has never before been taken in the District of Columbia. It occured in hundreds this season at the point where the observations were made. (3.) Almost no observations are upon record regarding the early stages of the family Anthicidæ. Of the 130 odd North American species the larvæ of none have heretofore been observed.

Mr. Dall showed some fat still containing a

quantity of dried muscular fibres obtained under the following conditions: The geological horizons known as the 'Kowak clays' and the 'Ground ice formation,' from which mammoth remains have been obtained on the Arctic coast, especially at Elephant Point, Kotzebue Sound, appear to be represented in the river deltas of the northern coast of the peninsula of Alaska. Here, near the mouth of the Naknek River, in the spring of 1894 the freshets cut away the clays until the falling bank revealed mammoth bones in the newly exposed portion. The spot was visited by the natives who obtained mammoth bones and a large quantity of fat which they used in greasing their skin boats. The quantity is estimated at 300 pounds. A little later the locality was visited by Mr. W. J. Fisher, who reports that the cavity in the bank of frozen clay still retained something of the form of the body of the mammoth, and under the organic débris, bones, etc., at the bottom, he obtained a piece of the fat in good preservation, which he presented to Mr. Dall, who now exhibited it. Mr. Dall recalled that at Kotzebue Sound, in cavities of the ground ice, he obtained what he believed to be dung of the mammoth, still having a strong ammonical smell. It would seem that the present carcass had been more or less demoralized before it was imbedded in the clay, as no mention is made of the existence of hair or skin in connection with the remains, only of disintegrated muscular tissue, bones and fat.

Dr. Wardell Stiles spoke briefly of the proposed memorial to Dr. Rudolph Leuckhardt and of the steps taken by the recent International Zoölogical Congress in regard to the adoption of an international code of nomenclature.

Dr. C. Hart Merriam spoke on the American Shrews. From a study of about 2,000 specimens he recognizes 60 species and subspecies, 11 of which are restricted to southern Mexico and Guatemala. Of the total number, 18 belong to the genus *Blarina*, 2 to *Notiosorex* and 40 to *Sorex*. The latter genus is subdivided into the 3 subgenera usually recognized — *Microsorex*, *Neosorex* and *Atophyrax*.

F. A. Lucas,
Secretary.

THE ACADEMY OF SCIENCE OF ST. LOUIS.

The first Fall meeting of the Academy was held at the Academy rooms, Monday evening, October 21st. Prof. Francis E. Nipher made a donation to the Academy of his new volumne on 'Electricity and Magnetism.'

Prof. Wm. Trelease read a paper on 'The Gases Produced by Certain Bacteria,' by L. H. and Emma Pammel.

President Green made mention of the death of Prof. C. V. Riley, one of the former Presidents of the Academy, and announced that he would appoint a committee to prepare a suitable memorial of Prof. Riley's death.

A. W. Douglas,
Recording Secretary.

NEW BOOKS.

Elements of the Mathematical Theory of Electricity and Magnetism. J. J. Thomson. Cambridge, The University Press. New York, Macmillan & Co. 1895. Pp. vi+510. $2.60.

An Introduction to General Biology. William T. Sedgwick and Edmund B. Wilson. Second edition. New York, Henry Holt & Co. 1895. Pp. xii+231.

Elementary Physical Geography. Ralph S. Tarr. New York and London, Macmillan & Co. 1895. Pp. xxxi+488.

Charles Lyell and Modern Geology. T. G. Bonney. London, Cassell & Co. New York, Macmillan & Co. 1895. Pp. vi+224. $1.25.

Missouri Geological Survey, Vol. II. Charles R. Keyes. Jefferson City. 1895. Pp. 405.

Elements of Geometry. George C. Edwards. New York and London, Macmillan & Co. 1895. Pp. xii+293. $1.10.

Science and Art Drawing, A Complete Geometrical Course. J. Humphrey Spanton. London and New York, Macmillan & Co. 1895. Pp. xiv+582. $3.25.

Reconnoissance of the Gold Fields of the Southern Appalachians. George F. Becker. U. S. Geological Survey. 1895. Pp. 85.

Catalogue of the Marine Mollusks of Japan with Descriptions of New Species and Notes on Others Collected by Frederick Stearns. Henry A. Pilsbry. Detroit, Frederick Stearns. 1895. Pp. vi+196.